

The WHAT'S NEW magazine

MAY 1986

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THE
ELECTRONIC
REVOLUTION
IN POWER
STEERING

Popular Science

Coast to coast in minutes:
Engineering next-generation

SPACE PLANES



Low-cost word processors for your home
New airport X-ray spots invisible terrorist weapons

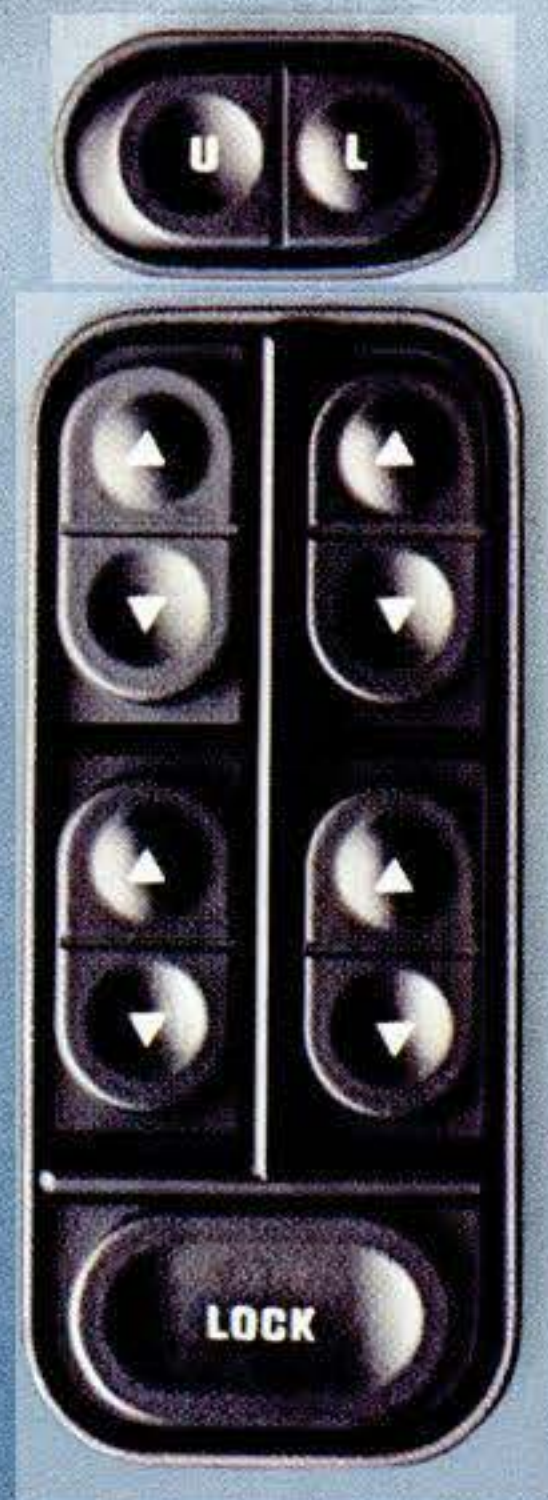


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Tailgate parties are popular with many wagon owners. So Ford designed an optional picnic table that folds out of the cargo floor and extends over the bumper.

THE NEW TAURUS PROOF THAT A WAGON CAN BE FULL OF CARGO



The tactile controls on the LX are designed so they can be operated by feel, allowing the driver to keep his or her eyes on the road.

The Taurus Wagon is one of the most well thought-out automobiles on the road today.

It's full of advantages. From 81 cubic feet* of cargo space (with the second seat down) to dozens of features that not only answer the needs of the driver, but those of the passengers as well.

The Taurus Wagon.

It's loaded with exceptional thinking.

Flush fitting glass reduces wind turbulence which means less interior wind noise.





The optional electronic instrument panel is designed to be "user friendly." All instruments are easy to read and all controls are placed where your hands can easily find them.

BRONCO WAGON. IT DOESN'T HAVE TO BE LOADED.

The best-built American cars.

At Ford, Quality is Job 1. A 1985 survey established that Ford makes the best-built American cars. This is based on an average of problems reported by owners in a six-month period on 1981-1984 models designed and built in the U.S.

*Based on 1986 EPA Cargo Volume Index.



The illuminated mirror on the passenger side of the LX slides out from inside one of the dual sun visors, so it can be adjusted close to the face.

Have you driven a Ford... lately?



This One



BFSQ-2BR-RNBR

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Spaceplane—coast to coast in 12 minutes

Development of a plane to travel at hypersonic speeds is taking off in the U.S. and Britain.

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Chunnel for the channel

After 200 years of dreams, a tunnel to link England and the Continent may be at hand.

50

Electronic revolution in power steering

It's lighter; it's more precise. Move over, hydraulics! Here comes electronic power steering.

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Six uncommon houses

Start building: Here's a handsome portfolio of innovative designs from big-name architects.

Cover illustration by Dean Ellis

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Win the Mobil 1 Corvette

in the Great Corvette Giveaway Sweepstakes



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SWEEPSTAKES OFFICIAL RULES—NO PURCHASE NECESSARY

You are automatically entered in the Mobil "Great Corvette Giveaway" Sweepstakes when you submit your request for the Mobil "Motor Oil Rebate", using this certificate. Due to State laws, rebate certificates obtained at service stations will not be entered into the sweepstakes drawing in the following states: Maine, New Hampshire, Massachusetts, New Jersey, Maryland, Virginia and Nevada.

If you do not wish to qualify for a rebate, but want to enter the sweepstakes, you may enter by completing this certificate or by simply hand-printing your name, address and zip code and the name "Mobil" on a 3" x 5" piece of paper and mailing it to: "Great Corvette Giveaway" Sweepstakes, P.O. Box 4556, Reidsville, NC 27322-4556. Vermont residents only: "Great Corvette Giveaway" Sweepstakes, P.O. Box 4592, Reidsville, NC 27322-4592. Enter as often as you wish, but each entry must be mailed separately and postmarked by July 21, 1986. Mobil Oil Corporation will not be responsible for late, misdirected, lost or stolen entries. Vermont residents will have postage returned.

Mobil Oil Corporation will award the following prizes in this promotion: One Grand Prize—Custom 1986 Mobil 1 Chevrolet Corvette with standard equipment, including V-8 engine, air conditioning, power steering, power brakes, power windows, Eagle GT tires, and AM/FM stereo radio (\$30,000 Value); ten First Prizes—Custom Mobil 1 Corvette Mini-Car (\$700 Value); and one thousand Second Prizes—Custom Mobil 1 Radio-Controlled Racer with battery-operated remote controller (\$49.95 Value—6 AA 1.5V and 4 C cell 1.5V alkaline batteries not included).

4. During the week of August 18, 1986, winners will be selected at random from all valid entries received, by Glendinning Associates, Inc., an independent judging organization whose decisions are final on all matters relating to this sweepstakes. Participants whose entries are selected will be notified by mail and may be requested to sign and return within 30 days of notification, a form certifying their eligibility for participation in this promotion and release regarding prize awards. In the event of non-compliance with the 30-day time period, an alternate winner will be selected. All prizes returned to the sponsor or to Glendinning Associates, Inc. as undeliverable will be awarded to alternate winners. Limit one prize to a family or household. Prizes are not transferable and no substitution is allowed. Dealer prep charges, license and registration not included. Please allow 6-8 weeks after validation for prize shipment. Taxes on prizes are the sole responsibility of the winners. The odds of winning are determined by the number of entries received.

5. Sweepstakes participation is open to all licensed drivers that are residents of the U.S. except the employees and their immediate families of Mobil Oil Corporation, its subsidiaries, agents and Glendinning Associates, Inc. This offer is void wherever prohibited or restricted by law and subject to all Federal, State and local laws and regulations.

6. For the names of the Grand and First Prize winners, send a self-addressed, stamped envelope to "Great Corvette Giveaway" Sweepstakes Winners List, P.O. Box 4557, Reidsville, NC 27322-4557 by August 8, 1986.



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- ☐ **Send me a \$1.25 rebate.** I have enclosed 5 proofs-of-purchase (5 UPC Codes [fiber container] or 5 aluminum seals [plastic container]) from 5 quarts of Mobil Super or Mobil Heavy Duty Motor Oil, and a dated, original proof-of-purchase receipt with the price of the oil circled. To remove the 5 UPC Codes from the fiber containers, simply cut around the symbols carefully with a single-edge blade. To remove the aluminum seals from the plastic containers, simply cut around the inside of the necks carefully with a single-edge blade. Record the UPC Code number in the space provided below.

Fill out this coupon and mail it with your proof-of-purchase UPC Codes or aluminum seals and receipt to:

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plastic and fiber containers**

Readers Talk Back

Address letters for this column to: Readers Talk Back, POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. Because of the large volume of mail, we are unable to acknowledge unpublished letters.

Smoky burnouts!

"How Engineers Will Break the Front-Drive Hp Barrier" [Jan.] overlooked six very exciting years when front-drive cars dominated Indianapolis Motor Speedway. Their run started in 1946 with Ralph Hepburn driving the front-drive Novi Governor Special [see photo], which qualified at 134.45 mph—a track record at the time. In 1947, a front-drive Blue Crown Special driven by Mauri Rose won. In 1948 another Novi set the fastest qualifying

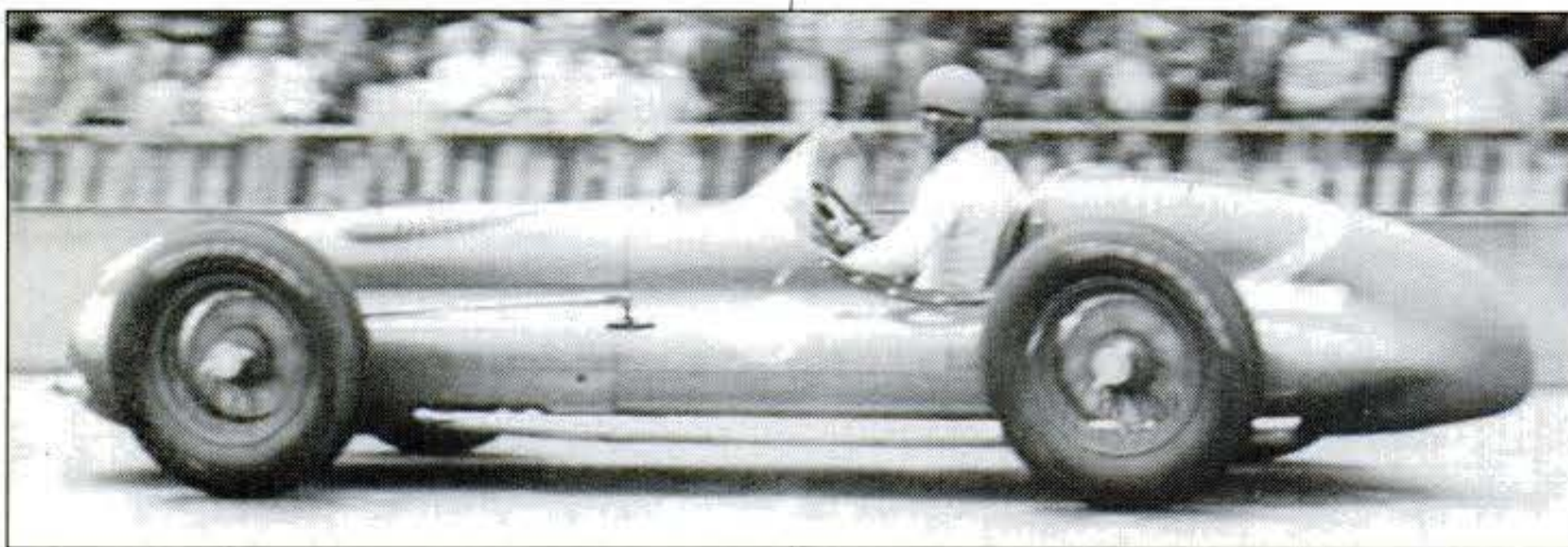


PHOTO: INDIANAPOLIS MOTOR SPEEDWAY

time. In 1949 Bill Holland won the race in a front-drive Blue Crown Special, and a Novi set the fastest qualifying time. Again, in 1952, the fastest qualifier was a Novi.

The Novi racers reportedly had 500 hp under their sleek hoods. The cars were hard on tires, though. Newsreels often showed the cars racing along, with smoke pouring off their front tires!

Harold Wooster, Bethesda, Md.

Roller derby

There's a much better method of roller painting than that shown in January's "Wordless Workshop." Instead of using a stepladder or footstool, simply attach a four- or five-foot extension handle to the roller and work from the floor. This way is faster, minimizes bending, and eliminates the possibility of falling. You can buy an inexpensive—under \$5—extension handle in any paint or hardware store, or make one from an old broom handle.

Charles Meyers, Gulf Breeze, Fla.

4-wheel steering and drive

Is there a car maker studying four-wheel drive *plus* four-wheel steer-

ing? That combination would seem unbeatable.

Robert Birch, Northridge, Calif.

Jack Keebler replies: "Three Japanese auto manufacturers—Mazda, Nissan, and Toyota—have been road testing four-wheel-drive, four-wheel-steering prototypes. The makers suggest that as early as 1990 they'll be mass-producing such models. If U.S. car makers are working on the combination, they're keeping quiet about it. And European manufacturers seem to be discounting

four-wheel steering as merely a parking device."

That's commuting!

"Fastest Bike in the World" [Feb.] didn't mention that the International Human Powered Speed Championships weren't just for HPVs that go fast in a straight line. There were also road and velodrome races, plus a commuter-vehicle competition. The winning commuter vehicle [see photo] can carry six bags of groceries in pannier bags alongside the front and rear wheels and under the seat. A briefcase can be tucked under the rear fairing. The All Weather, All Purpose Easy Racer also has a windshield and fabric fairing to keep the rider dry. And in the 200-meter sprints compe-



Continued

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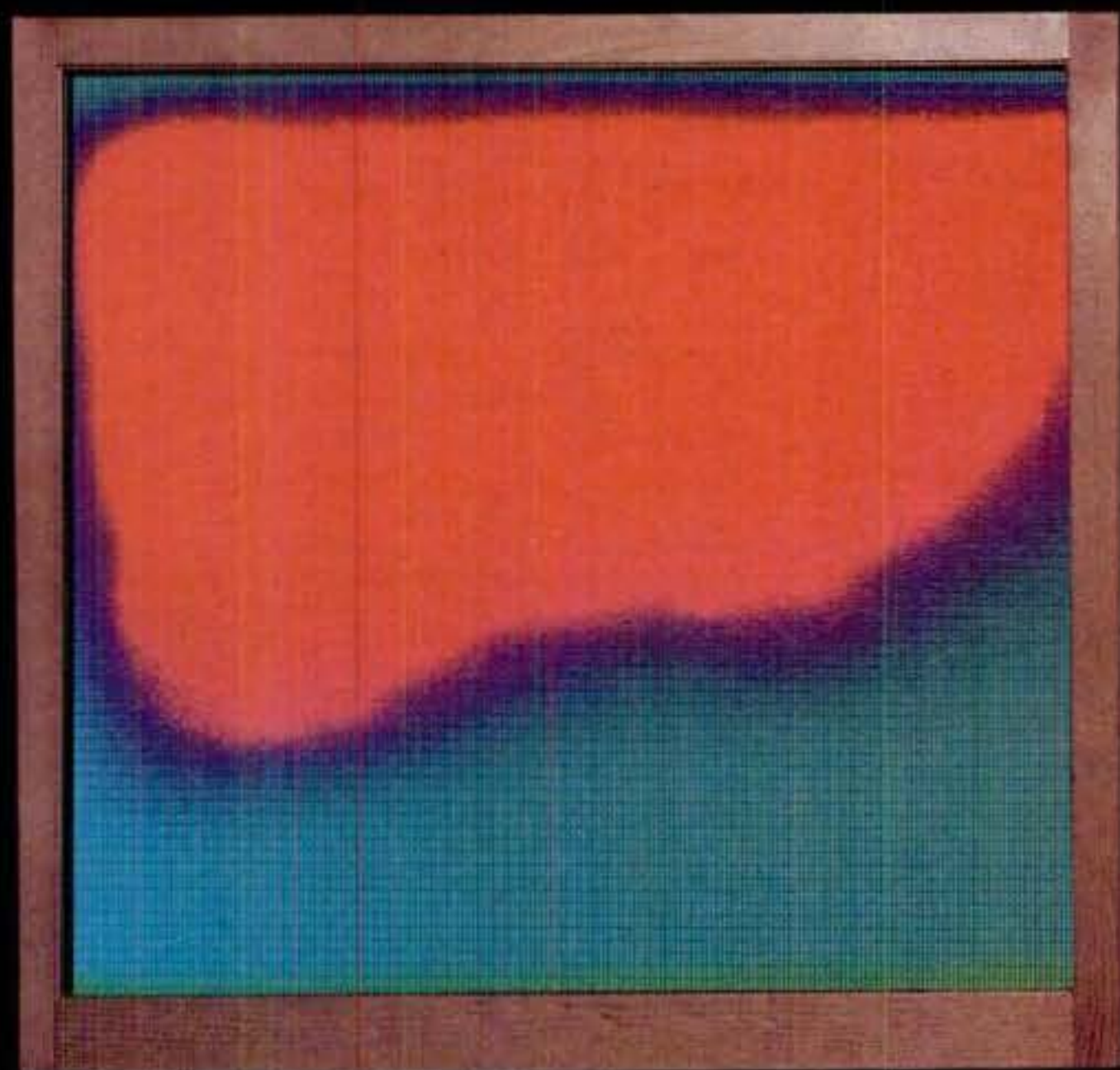
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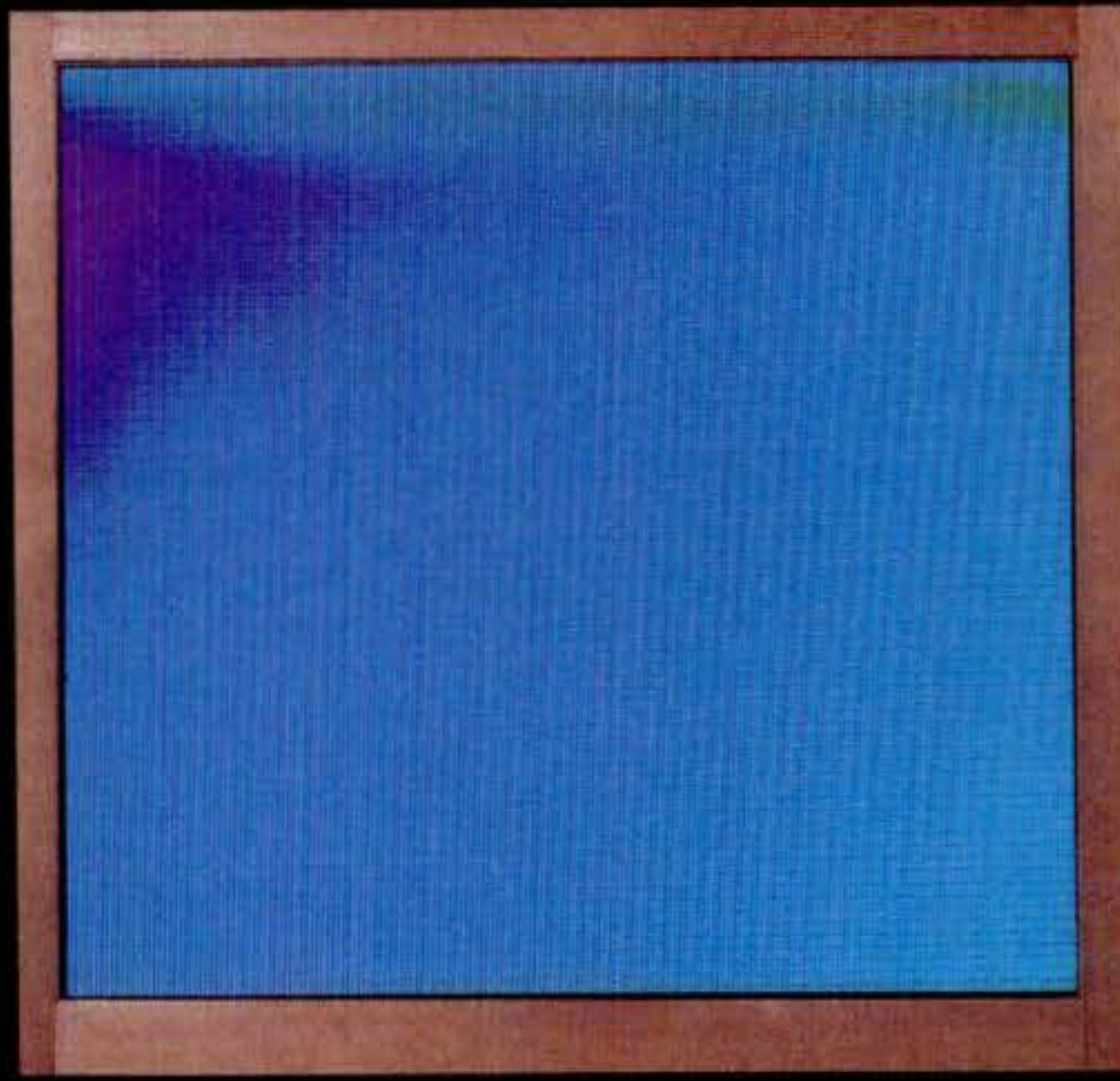
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tion, it turned in a time of 35.2 mph. Now, that's commuting.

Michael Eliasohn
Intl. Human Powered Vehicle Assn.
Seal Beach, Calif.

A Legend? Maybe

"Driving a Legend" [Feb.] shows an illustration of the Honda's valve-train layout, which you call unique. You may be interested to know that the prewar two-liter engine of BMW's 327 and 328 models had an identical across-the-head valve-train layout. The engine looked like a twin overhead-camshaft unit.

Glenn M. A. Levering
Vancouver, B.C.

Jack Keebler replies: "Several experts and sharp-eyed readers have called our attention to other examples of this unusual—but not unique—valve-train layout."

How we pick 'em

Why didn't December '85's car test ["Europe's Fastest, Best-Handling, Quickest-Stopping 4-Doors"] include the Peugeot 505 turbo, which would certainly compare favorably with the group tested?

F. Marion Moise III
Charleston, S.C.

And why did you test, yet again (see the August '85 and January '86 car tests), a BMW?

Paul M. Webb, Racine, Mich.

Jack Keebler replies: "We were limited by editorial space to four vehicles, and we chose the four top sellers in this class."

What, no TV?

There's one glaring error in "PS Leisure Home: Media-Center Retreat" [Feb.]: too much light in the media room. Bright daylight will make watching the TV or the viewing screen extremely difficult. I suppose you could draw the drapes across the windows when you want to watch. But you can't cover the bubble skylight. And audio and video components should not roast in the sun, either. I love the idea of having a fireplace, TV, and expansive view of the countryside in one room, but it just isn't practical.

Dave Weatherwax, Fairfield, Ill.

Al Lees replies: "It's true—bright sunlight can obscure the image on projection TV, assuming the media center

will be used in bright sunlight. Surely anyone visiting a vacation home will be enjoying outdoor activities on such a day; TV watching would be confined to evenings. For addicts who can't wait till nightfall, drapes would be needed, as well as skylight louvers [PS, Dec. '85]. You'd want both for winter insulation anyway."

Codes say no

Please caution readers not to construct additions like "Vaulted Sunspace" [Jan.] in front of bedroom windows unless the rooms have other means of direct egress. All building codes in the United States require that a bedroom have either a primary or secondary means of direct egress. Some solar-house designs could have significant safety problems unless compartmentalization, draft-stopping (in envelope houses), or other means of fire containment are properly employed.

John M. Robinson, P.E., A.I.A.
Cumberland, R.I.

Al Lees replies: "Such codes are often 'adjusted' for specific structures. For example, many earth-sheltered houses have bedrooms with no direct egress to the outside. Their designers point out that getting from the bedrooms in the rear to the front is fast and easy."

Confused heads

In March's "New Products for Lawn and Garden," I think there's some confusion between a side-valve and an overhead-valve (OHV) engine design. I always thought valves were either in the block or in the head. Their being above the cylinder head or in it doesn't make sense.

Tom Berg, P.E., Seattle, Wash.

Timothy O. Bakke replies: "The article should have read, 'The main difference between an OHV and a side-valve, or conventional, design is that the intake and exhaust valves are located above the engine block instead of in it.'"

Power painting

Just a word of advice to do-it-yourselfers who plan to use the excellent Homax power paint roller ["Power Paint Rollers," Jan.]. Getting the residue paint out of the hose—which is fortunately clear—may be difficult. I used Amway Industroclean, diluted 1:1, which did the job and didn't damage the unit.

Robert Fleming, Tustin, Calif.

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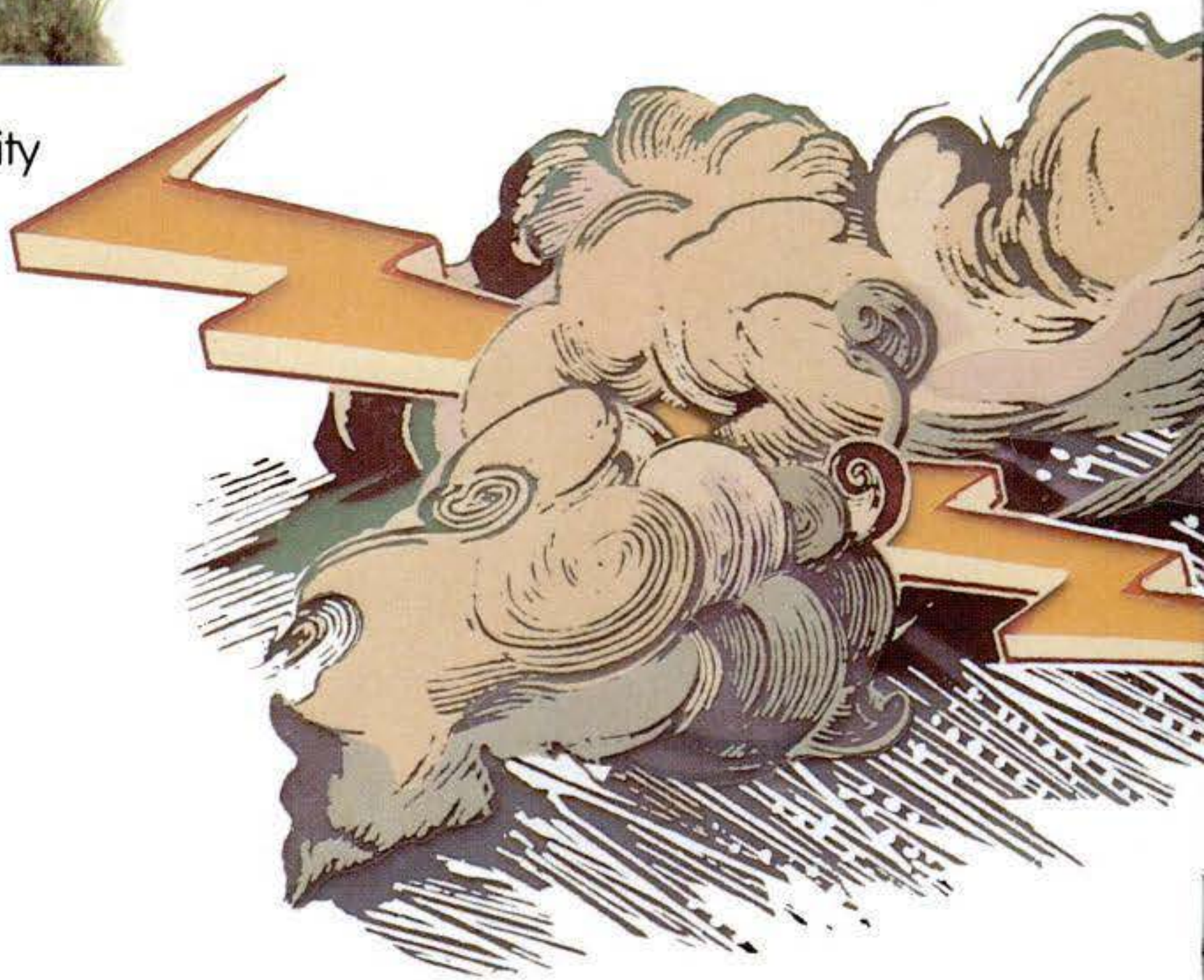
Big loads aren't a big deal for the XCH4 radial. It gives you the carrying capacity of a light truck tire. And because a Michelin never forgets, the XCH4 also provides the comfort of a Michelin passenger tire.



Michelin believes a tire should be seen (the XCH4 is really sharp) but not heard. The XCH4's unique tread design is inherently quiet. So it reduces highway hum—the nerve-racking racket common to aggressive tires.



Anyone can make a tire that looks tough. The trick is to make it last. The XCH4 is designed to wear slowly, and just as important, evenly. Which prevents premature wearout. And gives you the kind of mileage Michelin is famous for.

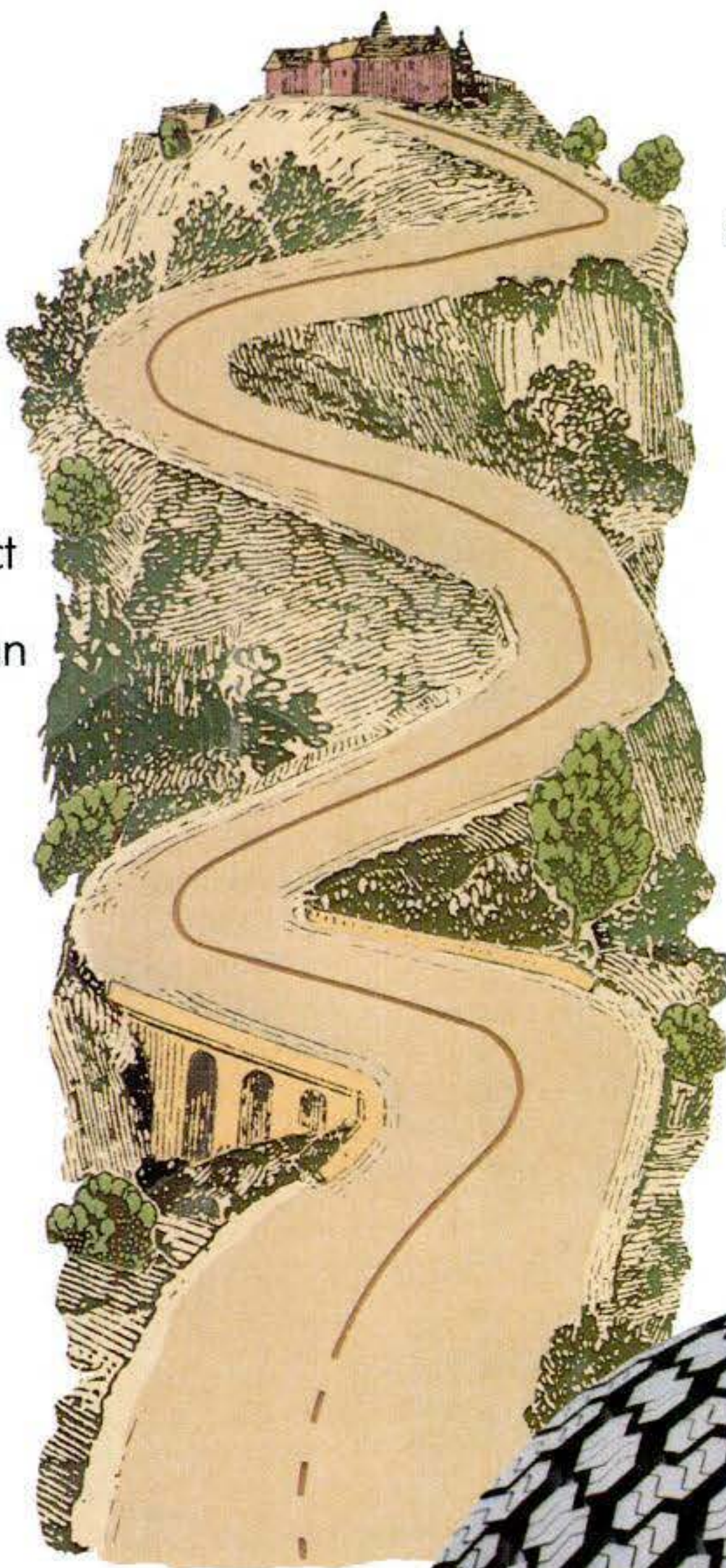


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Science Newsfront

By ARTHUR FISHER



Chip failure—live on TV

The picture above shows a potentially disastrous transistor condition called snapback, photographed live for the first time. In this computer-enhanced color-added infrared microscope shot taken from a TV screen, several transistors on a silicon integrated-circuit (IC) chip are glowing red. The emitted light is caused by high-energy electrons flowing through the affected components, and indicates snapback, a surge in current that can ruin an IC when it is left uncorrected.

In this Sandia National Laboratories experiment, engineers induced snapback by flashing a millionth-of-a-second pulse of xenon laser light on a 10-micron-square region of the IC chip, analogous to a burst of X-rays from a nuclear weapon. But snapback can also be caused by such routine sources as static electricity during wafer testing. Microelectronics experts say it could become a problem for the next generation of extremely small

ICs with elements measuring only 1.5 microns or less.

The snapback experiment was conducted at Sandia's Center for Radiation-Hardened Microelectronics, in Albuquerque, N.M.

Rubber plant

Natural rubber, it may surprise you to learn, is the largest strategically important commodity for which the U.S. is totally dependent on foreign sources. That's why a silvery-leaved desert plant named guayule (scientifically known as *Parthenium argentatum*) has been a focus of interest for years, as a potential new source of domestic natural rubber. It yields a rubber almost identical to that extracted from tropical rubber trees. But commercial development of the wild plant has been blocked by the inability to breed higher-yielding varieties.

Now that obstacle may be overcome. Dr. David N. Radin, a plant-cell geneticist at the University of Califor-

nia at Irvine, has developed a new cloning procedure specifically for guayule. It uses small pieces of living tissue from mature plants to start the growth of tissue cultures in test tubes. These cultures produce small shoots that are transferred to another culture medium that induces root growth. The completed plantlets are then grown in soil just as normal seedlings are.

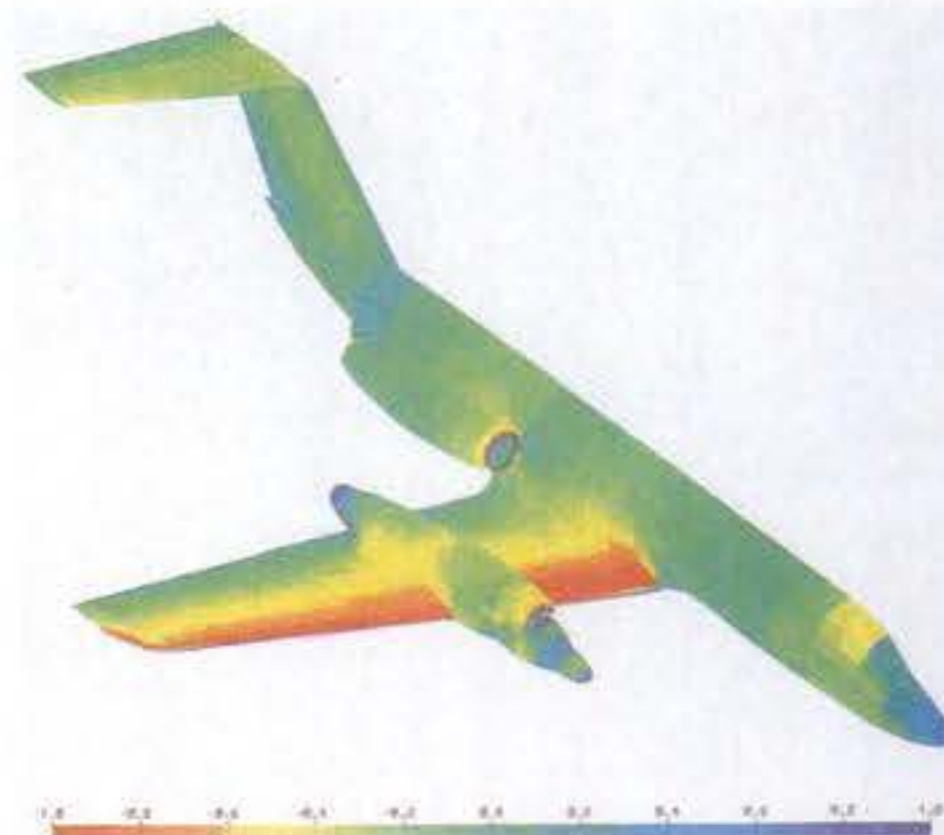
"Cloning," says Radin, "will give breeders a powerful and perhaps key tool... by permitting them to reproduce large numbers of genetically identical offspring from individual improved guayule plant selections.... If these preliminary tests prove successful, clonal reproduction could then be scaled up to provide the improved seed needed for crop production."

Radin's research is funded by the National Science Foundation through its Division of Molecular Biosciences.

Computing airflows

The picture below is an example of the burgeoning use of supercomputers and highly sophisticated mathematical techniques in the knotty field of fluid dynamics. Engineers at Lockheed-Georgia Co. have been trying to design the way in which the wing and nacelle of the Propfan Test Assessment (PTA) test-bed aircraft will fit together. The aircraft is a Gulfstream GII business jet that will have a nine-foot-diameter eight-bladed propfan mounted on the left wing.

One of the most time-consuming aspects of such design work is analyzing the aerodynamic flow fields over the aircraft's surfaces. Using a powerful new supercomputer, the Cray



X-MP/24, Lockheed engineers produced the simulation of the right-wing PTA configuration shown. In the computer-generated drawing, the colors indicate pressure coefficients. Red shows the highest negative pressures, and blue the highest positive pressures.

Continued



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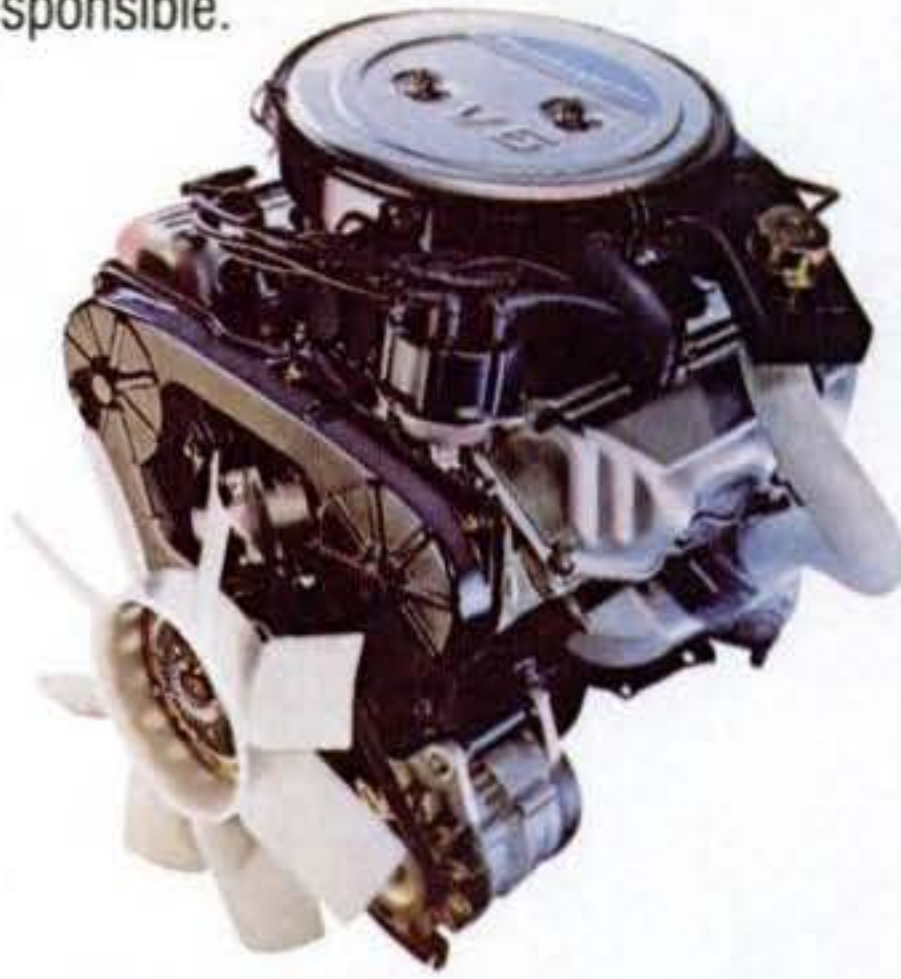
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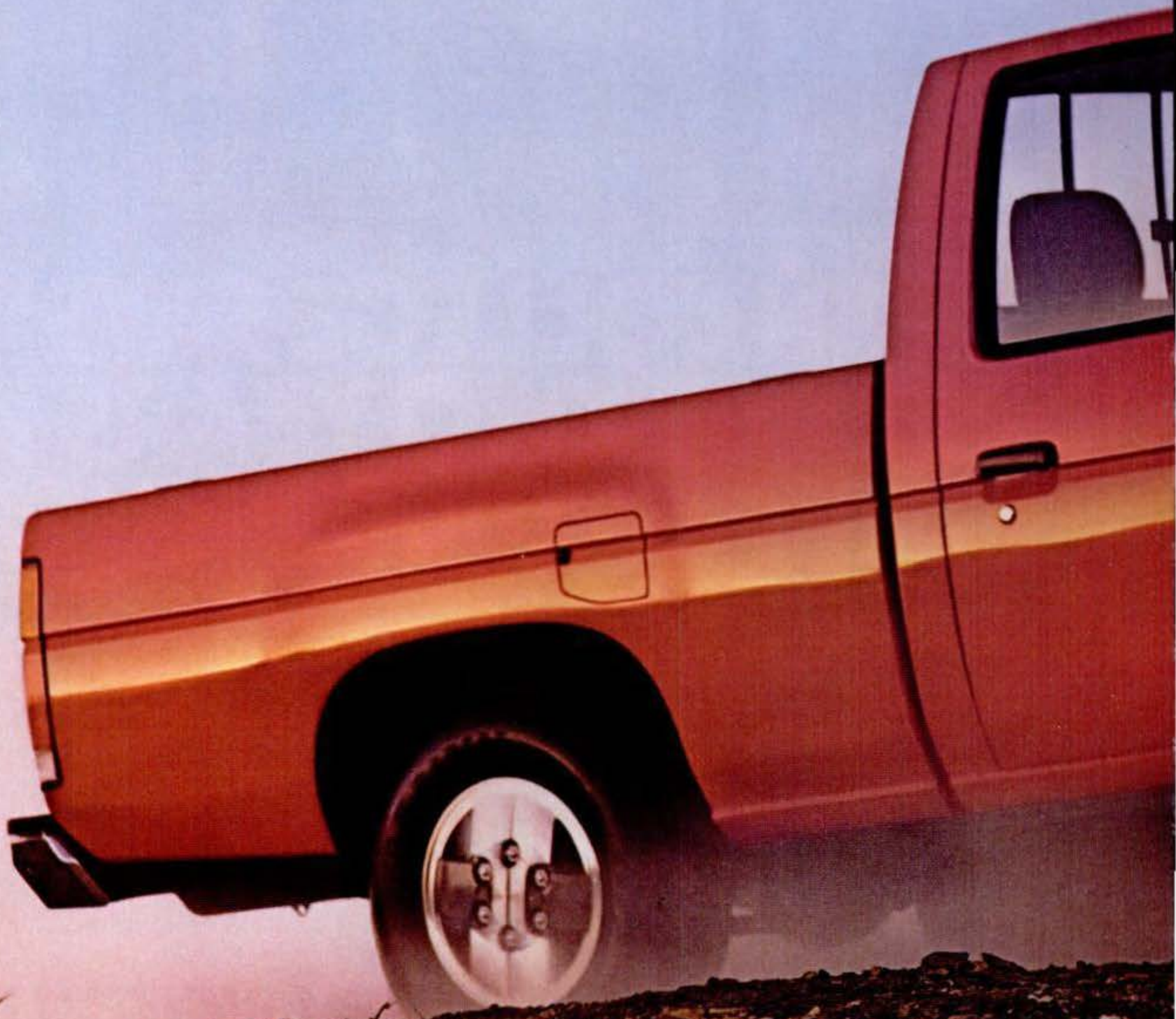
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OUTSIDE. Breakthrough design makes this truck a Hardbody. Aggressive styling matched to superior performance. Witness the sloped hood. Raked windshield. Airfoil profile. Flared fenders. These elements aren't simply a matter of form. They're a function of aerodynamics designed to improve performance, reduce noise and deliver a smoother ride.

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INSIDE. The new cab is Nissan's biggest, widest ever. More head, leg and shoulder room plus cloth upholstery and deep cut pile carpeting make this SE incredibly comfortable. New big side windows and a huge windshield provide exceptional visibility. New insulation produces a quieter ride.

Full instrumentation—including tach, voltmeter and oil pressure gauges—is laid out the way it should be.

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Power Package: power windows and door locks, cruise control, dual power outside windows, 4-speaker stereo radio/cassette deck, and variable-speed intermittent wipers.

Then add the Sport Package for a pop-up sunroof and big tires mounted on new alloy wheels.

Nissan SE 4X2. Hardbody hot.





tures. The computer model analyzed airflows over 5,400 surface elements—very small areas of the total surface being studied. The process took 22½ minutes on the Cray supercomputer. The same computation run on a large main-frame computer in use at Lockheed-Georgia took 48 hours.

Plant scan

Magnetic resonance imaging (MRI) is a fast-growing part of medical technology, a complement to CAT scanners, radionuclide imaging, and other advanced means of seeing inside the body. (MRI used to be called NMR, for nuclear magnetic resonance.) To describe it briefly, a subject is placed in the bore of a very powerful superconducting magnet and probed with high-frequency radio signals. Atoms of specific elements (such as hydrogen) inside the body become excited and resonate in a characteristic way. The resonance patterns are transmitted to a computer, which uses the data to

construct an image of the organ or body structure being examined.

All well and good. But then what's a bean plant doing in the MRI scanner seen in the photo above?

Simple. Scientists from General Electric Co. and the U.S. Department of Agriculture are collaborating to use MRI to probe the role of roots in plant growth, and thus help optimize growing conditions for crops. In the photo, Dr. Hugo Rogers (left), a USDA plant physiologist, and Dr. Paul Bottomley, a GE research physicist, are positioning a bean plant in the scanner's cylindrical bore. The magnet's field is 1.5 teslas, 30,000 times the strength of Earth's own magnetic field.

Nuclear safeguards

Compare the patterns of white dots in the photos below, each taken of the same special seal but at different times. The patterns are different. And that would be a tip-off to an inspector of the International Atomic Energy

Agency (IAEA) that the seal had been tampered with and that someone had gotten at nuclear material or surveillance equipment.

The tamper-indicating system is being evaluated by the Vienna-based IAEA as part of its constant quest to make sure the agency can detect any attempt to divert nuclear material from peaceful uses to the manufacture of nuclear weapons in countries that have consented to the presence of safeguards. The seals work like this:

Agency inspectors thread a length of 0.087-inch-diameter plastic cable, which contains 64 randomly twisted optical fibers, through the device being secured—a container of enriched uranium, say. Both ends of the cable feed through a rectangular hole in the center of the seal body to form a shackle. The inspectors then insert a specially designed serrated blade through a slit in the body. The blade severs between 40 and 60 percent of the cable's 0.005-inch-diameter acrylic optical fibers, creating a unique pattern of dots (the fiber ends) when light is shone through them. This signature is then photographed.

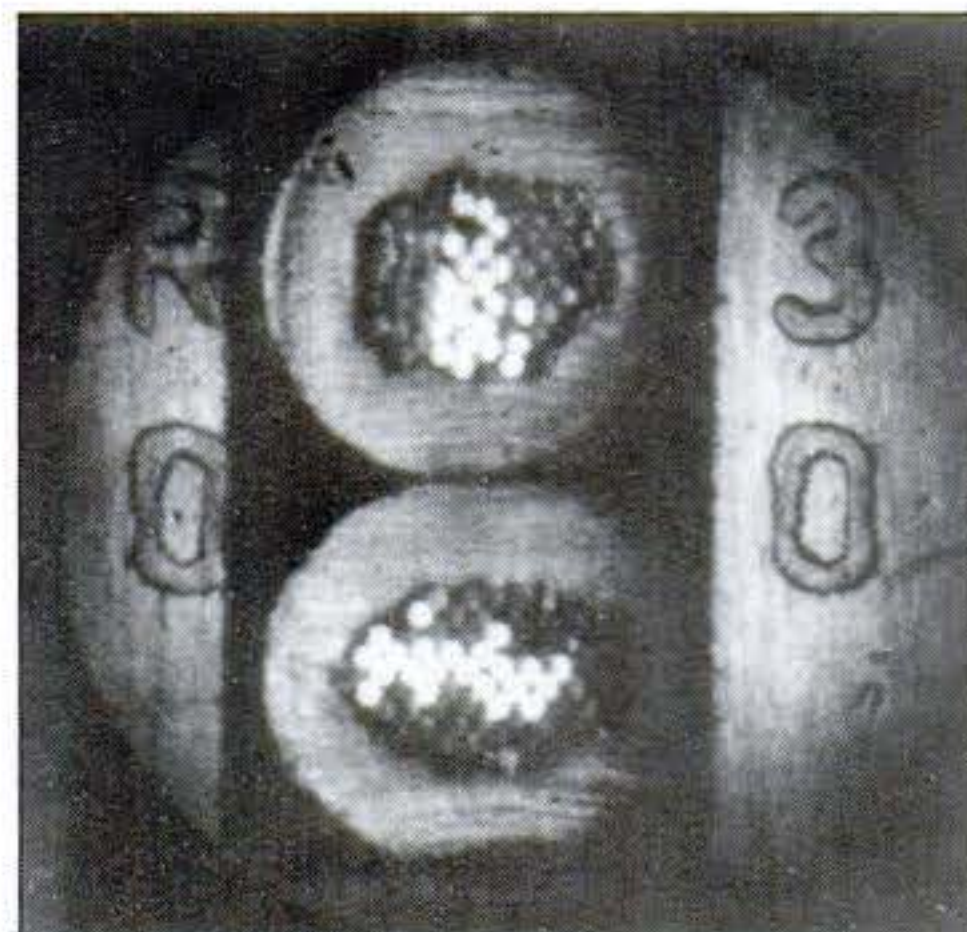
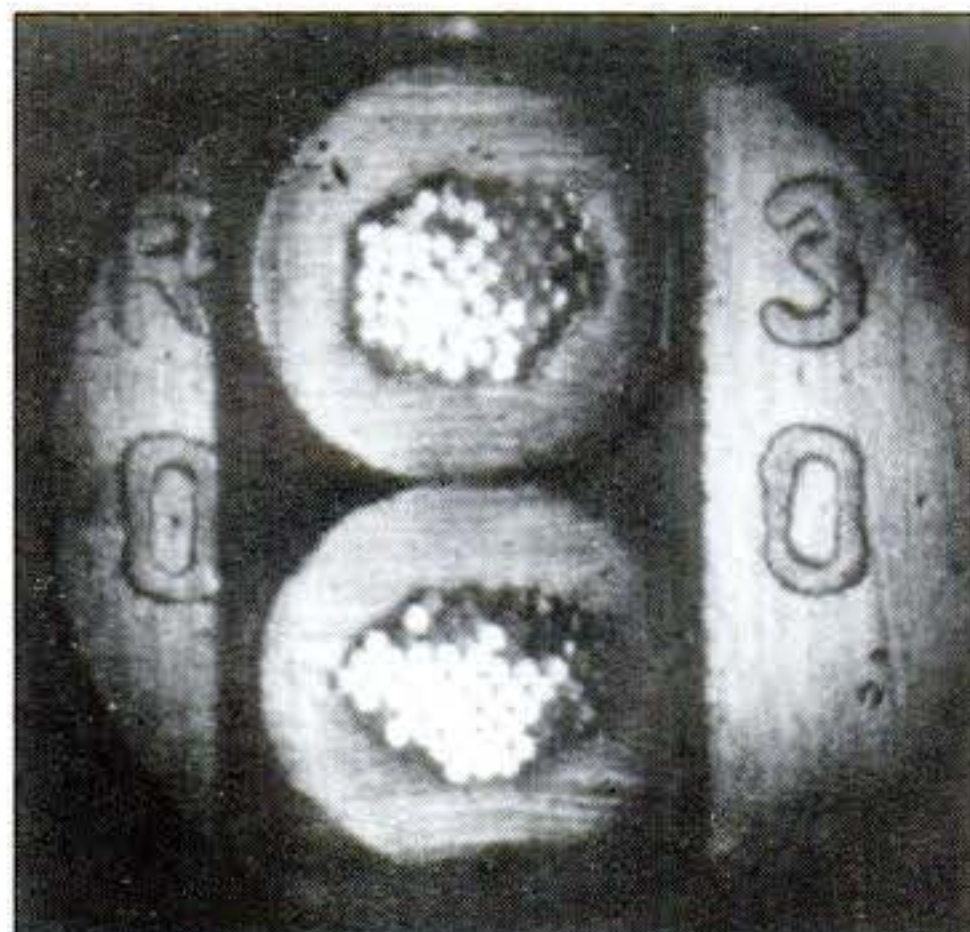
The blade also secures the fiber bundle in the seal. Any attempt to tamper with the seal by removing the blade will sever more fibers, altering the pattern for good.

Development of the seals was a joint project of the Atlantic Research Corp. of Alexandria, Va., and Sandia National Laboratories, under the sponsorship of the U.S. Department of Energy's Office of Safeguards and Security.

Detecting prostate cancer

Research at The Johns Hopkins Hospital in Baltimore, Md., suggests that ultrasound could be an important tool in improving the early detection of cancer of the prostate, which kills some 20,000 men a year in the United States. The painless and non-invasive technique works by bouncing high-frequency sound pulses off the tissues to be imaged; the return echoes are converted to a visual display. In a study of 52 Hopkins patients with known prostatic cancer, ultrasound examination before surgery identified tumors in three-quarters of the men. Physician Wolfgang Dahnert of Hopkins says: "Ultrasound is the only imaging method that lets us detect differences among tissues within the prostate gland. We need more studies to extend the work we've done, but there is no question that ultrasound is worthwhile."

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Alternate-Energy Answers

By JAN F. KREIDER

Jan F. Kreider is a consulting engineer specializing in the design and economic analysis of solar-energy and energy-conservation systems. He is the author of several books on solar technology and a lecturer at the University of Colorado.

Solar-heating info

I'm trying to build a solar water-heating system for my house. Where can I get the pump and sensors?

Leonice J. Miller
Port Saint Lucie, Fla.

Pumps are the type used in any residential hydronic heating system, usually 1/20 horsepower or so for a closed-loop system. They are available from a home-heating contractor or supply house. Buy a differential controller and its sensors from a local solar contractor. Be certain that it has sufficient capacity to operate all pumps you propose to use. The controller should not cost more than about \$75.

Windmill direction

I'm considering building a windmill, and was looking through old volumes of POPULAR SCIENCE for ideas. I noticed that many windmills do not have tails to point them into the wind. How are they oriented into the wind?

Richard Doue, South China, Maine

Most modern aerogenerators use an electronic control system to orient the rotor into the wind. A small direction sensor (for example, a rheostat transducer similar to that found at local weather stations for wind-direction measurement) sends a signal to the controller. In turn, the controller operates a small motor that positions the aerogenerator head at the proper attitude to the wind.

Dewy preheater

About five years ago I installed a two-tank solar water-heating system. I have recently noticed condensation on the preheat tank in warm, humid weather. I'm concerned about tank deterioration because the insulation remains wet for an extended period. What should I do?

Dick Kuck, La Jolla, Calif.

The condensation is caused by the dew point of ambient air being above the water temperature in summer. There are a number of solutions. First, I suggest you surround the tank with a plastic vapor barrier after the insulation

dries thoroughly. This solution will not be perfect but should help. During summer, when solar heat is plentiful, you should isolate the preheat tank from the standard tank and heat it to high temperature occasionally to dry the insulation. A temporary opening in the vapor barrier will be needed for vapor exit. The isolation ensures that the tank will not be cooled by incoming water.

Chimney-cap advantage?

Would a chimney cap (one sold commercially by Consolidated Dutchwest Stove Co.), opened and operated when an oil burner goes on, save substantial heat on an average oil burner in an older, not fully insulated house in winter?

Fred Butterfield, Williamstown, N.J.

These devices save energy if the furnace is located in a heated space. Basically, they reduce the gravity-induced flow of warm air from a space through the furnace and out the stack. If the furnace is in an unheated space, however, the motorized dampers are of little benefit.

Stove near vent

I have an airtight wood stove in my second-floor living room that's located near a furnace return-air vent. Will the furnace help circulate heat to other parts of the building? Will the vent affect the draft of my stove?

Daniel J. Rooney
Staten Island, N.Y.

Very little heat will be introduced into the return-air system of your house unless a fan in the stove is connected directly to the duct. The placement of the vent near your stove will have no effect on the draft of the stove because the driving force for the draft is the temperature difference between the air source and firebox exit temperatures.

Basement insulation

I will soon be building my retirement home. It will be a two-story chalet-type structure on a concrete-block basement. I want to insulate the basement walls so I can have a warm rec-

reation room below ground level during Canadian winters. I propose to build the basement walls with two inches of styrofoam on the outside of the main block, with an outer four-inch block wall. Can you see any major flaws in this construction, and could you please suggest a good way to insulate the basement floor?

R. H. Bottomley, Belleville, Ont.

Your sandwich wall construction will work well. Be certain to use a vapor barrier plus a sealant on all below-grade walls to control moisture migration. A perimeter drainage system will keep ground water from seeping into the basement. The floor can be insulated by pouring concrete over rigid foam, but proper drainage is essential to keep the insulation as dry as possible. Another way to insulate a concrete floor was described in the September 1985 issue of POPULAR SCIENCE.

Ceiling insulation

I am installing a dropped ceiling and would like to put six inches of insulation above it to control heat loss to the apartment above. Will 24-inch-wide insulation work well on two-by-four-foot ceiling panels? Should I worry about a vapor barrier?

William Mount, Hawley, Pa.

The insulation you suggest will work well, though six inches is probably excessive. You need not concern yourself with a vapor barrier in this case.

Is wind power practical?

I'd like to know whether wind-produced electricity is an economical and trustworthy means of providing year-round electricity to a house. Also, is it better to store excess power using batteries or to sell it to a local power company?

Robert Dougan, Beaverton, Mich.

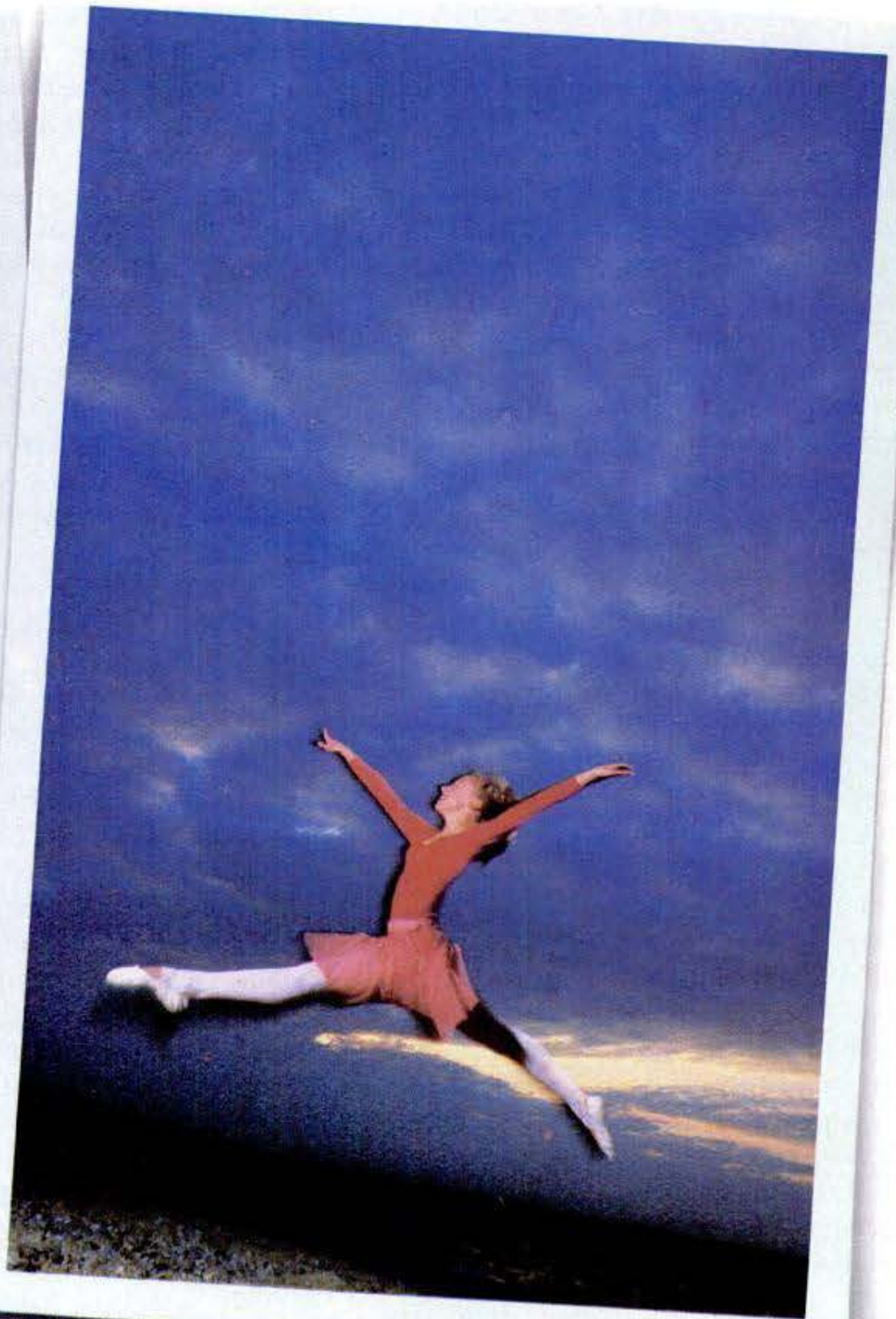
Under a special set of conditions, wind power may make sense: if you are 1) in a location where wind speed is consistently high; 2) in a state that offers renewable-energy credits; 3) in a utility district where the buy-back rate is above average; and 4) you're able to get a reliable unit with trained service personnel.

Do you have a question concerning use of an alternate energy such as solar, wind, water, or wood? Wondering about energy-conservation techniques for home heating or cooling? Every other month Jan Kreider answers selected questions from readers. Send yours to Energy Questions, POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. Queries can't be answered by mail.

Presenting a Nikon for total beginners who don't plan to stay that way.



This picture was taken by setting the N2000 in the programmed mode, focusing and pushing the shutter button. Simple.



This picture was taken in the manual mode, with a Nikon 15mm super-wide angle lens, between f 11 and f 16 at 1/4 second. Exposure compensation of + 1/2 stop, flash fill and skylight filter. Not so simple.



If you're new to 35mm SLR photography, there's no better place to begin than with the Nikon N2000.

It's auto-wind, auto-load, and can automatically set the film speed.

And with programmed exposure control, all you have to do is focus and shoot.

But you won't be a beginner forever. So the N2000 also has a high-speed programmed mode, aperture priority automatic and manual modes, TTL flash control, plus the ability to accept over 60 Nikon lenses.

So as you progress from beautifully simple pictures like the one on the left to complex beauties like the one on the right, one thing you won't have to change is your camera.

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Solar chimney for low-

A simple refinement of an ancient Middle Eastern cooling device—the wind tower—uses solar energy and water evaporation to lower indoor temperatures dramatically and cheaply.

By **RICK BOLING**

Illustration by Ed Lipinski

It was early last June, and the temperature had risen to 109 degrees F around Tucson, Ariz. Air-conditioner compressors groaned and evaporative coolers whirled as electricity surged through power lines. In one small frame house, however, a new cooling system was bringing back memories of spring by transforming the crackling heat into a gentle 74-degree breeze—at a cost of less than 10 cents a day.

If you had ventured outside into the huge barbecue pit that seemed to be surrounding most of the Southwest that day, you might have noticed that this particular house had what appeared to be not one, but two chimneys. These two structures—a wind tower and a solar chimney—are the chief components of a new system that could eventually replace many conventional air conditioners in low-humidity areas.

The system, which is incorporated into a 1,000-square-foot experimental structure at the University of Arizona's Environmental Research Laboratory, has been an unqualified success. It keeps the interior temperature of the house in the low 70s during typical Arizona summer days, when the mercury usually hovers between 95 and 100 degrees F.

Something old, something new

Combining a centuries-old technique with some new ideas, William Cunningham and his colleagues at the university have created a passive, low-maintenance system that will cool a house in the peak of summer at a cost of about \$3 per month. Even this cost could be eliminated by the addition of a small (perhaps three-foot square) solar panel to power the tiny pump.

"What we're looking at," says Cunningham, "is perhaps the lowest-cost method yet devised to cool a structure—any structure, from a residence to a greenhouse to a shopping mall."

For centuries, Iranians and others in the Middle East have used wind towers to cool their homes. Deflectors at the tops of these roofed towers catch

the wind and direct it across a pool of water at the base. Water evaporates, cooling the airstream, which then flows through the house. The problem with traditional wind towers, however, is that when the wind dies down, so does the cooling effect. What makes the University of Arizona system unique is that it works when the wind doesn't.

Starting with the wind-tower concept, Cunningham and his colleagues modified and improved it so that it doesn't rely on external breezes; it creates its own. At the top of the tower, excelsior pads are moistened with water delivered by a 1/15-hp submersible pump. Air passing over the pads becomes heavy with water vapor and sinks to the bottom of the tower at a speed of 100 to 300 feet per minute. An opening in the bottom of the tower allows some 3,000 cubic feet of cool air per minute to flow continuously into the house. Thus the tower works even without a wind. But when the wind does blow, the volume goes up and can double with a 20-mph wind.

The researchers improved airflow further by installing a solar chimney on the opposite end of the house. This 25-foot-high structure has openings at the top that let the sun strike panels of black-painted sheet metal. Because air temperature inside the chimney can reach 112 degrees in the summer, the rising hot air gives an extra pull to keep the cool air from the tower moving through the house.

Finally, the system also takes advantage of passive elements such as the accumulated heat in the attic. Cunningham points out that the attic has been redesigned to put the warm air inside it to work as an integral part of the convection cycle that drives the system. Air from the cooling tower enters the house on one end, travels through the building, rises into the attic, and is then pulled outdoors through the solar chimney.

"We have a baffle down the roof's center ridge, which causes the air to make two passes through the attic before it is exhausted into the chimney. Not only does this help heat the air entering the chimney, it also cools the attic in the process."

Even though the system was designed and built from scratch, it cost only about \$4,000 to retrofit the experimental house and construct the towers. Future models could drop to around \$1,500 in cost, and be incorporated into the original design of a structure, making them less noticeable.

"Though we can envision a mass-produced system that will plug into existing structures, it will be a lot more cost-effective to integrate the concept into a new building in such a way that the towers will be a part of the structure," adds Cunningham.

Evaporative coolers (often called "swamp coolers") have been used in dry areas for years, but these are active systems that use squirrel-cage fans to move humidified air through a building. They can cost up to \$40 per month to run, and have higher maintenance costs than the university's system.

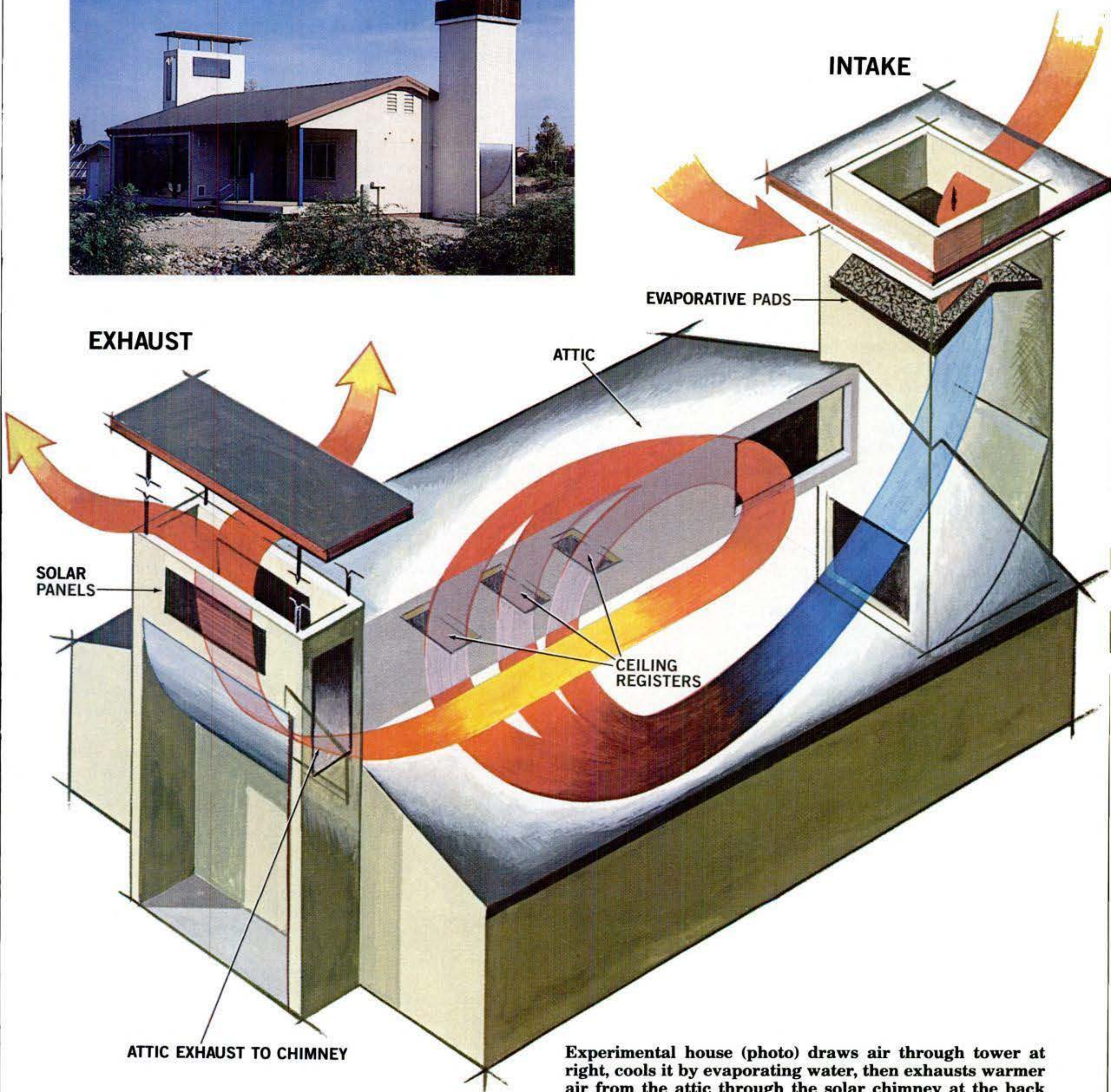
Greater simplicity to come

Cunningham says a new system now in the planning stages should be even less expensive, both to build and operate. "What we've learned while working with this system is that the solar chimney could be much shorter, or could even be eliminated in favor of motorless turbine vents in the attic itself. In the next generation of coolers we hope to eliminate the pump as well." One way could be to use the municipal water system's pressure to deliver water to the evaporative pads at the top of the tower. Run-over water would then be used to fill toilet tanks or for irrigation.

As the system now stands, maintenance costs include replacement of the small pump and evaporative pads every five years or so. The pads need to be changed because they gradually become choked with calcium, minerals, and salts from the water. If the researchers are successful, they will eventually create a system that uses no electricity, whose upkeep would involve only pad replacement. This could cost from \$10 to \$40 per year.

The university has applied for a patent, and hopes to license the new cooling technology to builders. **PS**

cost desert cooling



Experimental house (photo) draws air through tower at right, cools it by evaporating water, then exhausts warmer air from the attic through the solar chimney at the back end of the house. The system is designed for low-humidity areas. Diagram shows airflow through wetted pads in cooling tower into the living area of house. Air is next drawn through ceiling vents into the attic, where it follows a U-shaped path before exiting up the sun-warmed chimney. The system uses about 100 gal. of water daily.

Windows for your PC

—a paneless way of computing?

Goodbye, confusing keyboard computer commands. With Microsoft's Windows program, your PC-compatible computer displays a metaphorical desk top, and you do your work with a mouse or light pen.

By GORDON McCOMB

The logo says "IBM." But the computer's operation, and the display on the screen in front of me, reminds me more of an Apple Macintosh. Reason: I've been using Windows, a new \$99 program from Microsoft (16011 N.E. 36th Way, Redmond, Wash. 98052-6399).

Windows eliminates confusing prompts and commands on your IBM PC, XT, or AT. They're replaced by Mac-like windows, graphics, and mouse or light-pen operation. Also, Windows integrates software. It allows your computer to hold more than one program at a time, and individual programs can share information.

The idea behind Windows isn't new. Digital Research, Quarterdeck, and IBM each have competing products. However, Windows is the first to show signs of acceptance by a variety of major software companies and PC-compatible hardware makers.

Windows generally works well. But as I found out, that depends on how

it's used. When you start Windows, you see a "desk top." The display shows a menu bar of commands and a directory of programs or data files recorded on the disk. (File names are listed as text, not shown as icons as they are on the Macintosh.)

To choose a command such as copy a file, you slide a table-top mouse to highlight the on-screen menu selections; click the mouse when you reach the copy option. You can also make selections by pointing: Windows accepts a light pen. You can use the keyboard for control, too, but you must use the up and down arrow keys to step through the menus. It's tedious. My recommendation: Plan on adding a mouse or light pen to your computer.

Windows doesn't allow concurrent operation (more than one program running at once), but it does let your computer hold more than one program at a time. Each program is packed into a separate area of memory and shown in a window on the screen. You then select the one you want to use at the touch of a button.

Programs and commands are displayed in separate windows; the sizes and positions are adjustable. You make a selection with a mouse, light pen, or keyboard.

Windows comes with two full-size application programs: Windows Write and Windows Paint. Write is a medium-power word processor with easy-to-use features. Paint is a MacPaint-like program that draws in color (with the Enhanced Graphics Adapter) or black and white. Both programs can share each other's data, so you can paste pictures and text together.

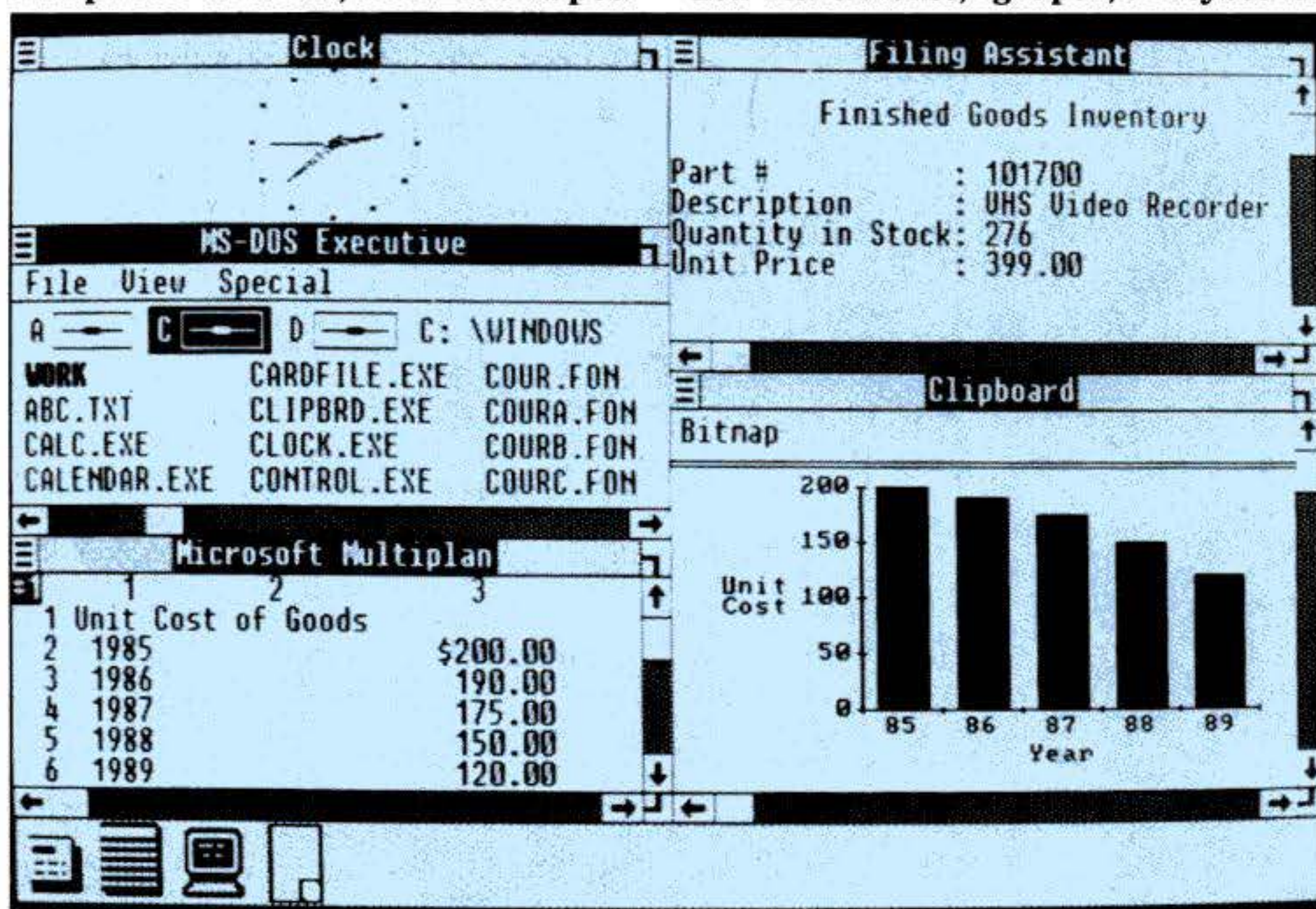
Only a few other programs written specifically to take advantage of Windows' graphics, data sharing, and desk-top capabilities are currently available. But some 100 existing programs can be displayed in separate windows after being converted by special adapter programs (called Program Information Files) included with Windows.

Although Windows is easy to use, it requires lots of memory. For example, my 640-kilobyte computer couldn't hold more than two medium-size programs in memory at once. When I tried to enter a third, I saw an on-screen message warning me that there was not enough memory. For more space—up to four megabytes—you must add a memory-expansion board, such as Intel's Above Board.

The program is also relatively slow: It takes up to 15 seconds to switch from one program to another (although that's faster than the time it takes to leave one program and enter another from disk). I also found Windows to be slow in other areas, particularly when manipulating the size and position of windows or issuing commands. Because Windows uses many support files held on disk, you must often swap disks on a two-drive floppy-disk system (the minimum requirement). A hard disk or RAM disk (memory that's set aside to act like a disk drive) speeds the program's operation considerably.

At present, Windows' outlook is still foggy—that will depend on the amount of software available for it in the future. But its advantages are clear: simple, more powerful operation of your PC from an inexpensive add-on.

PS



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Automotive Newsfront



PHOTO BY GREG SHARKO

The Pontiac Trans Sport hints at the shape of vans to come from General Motors.

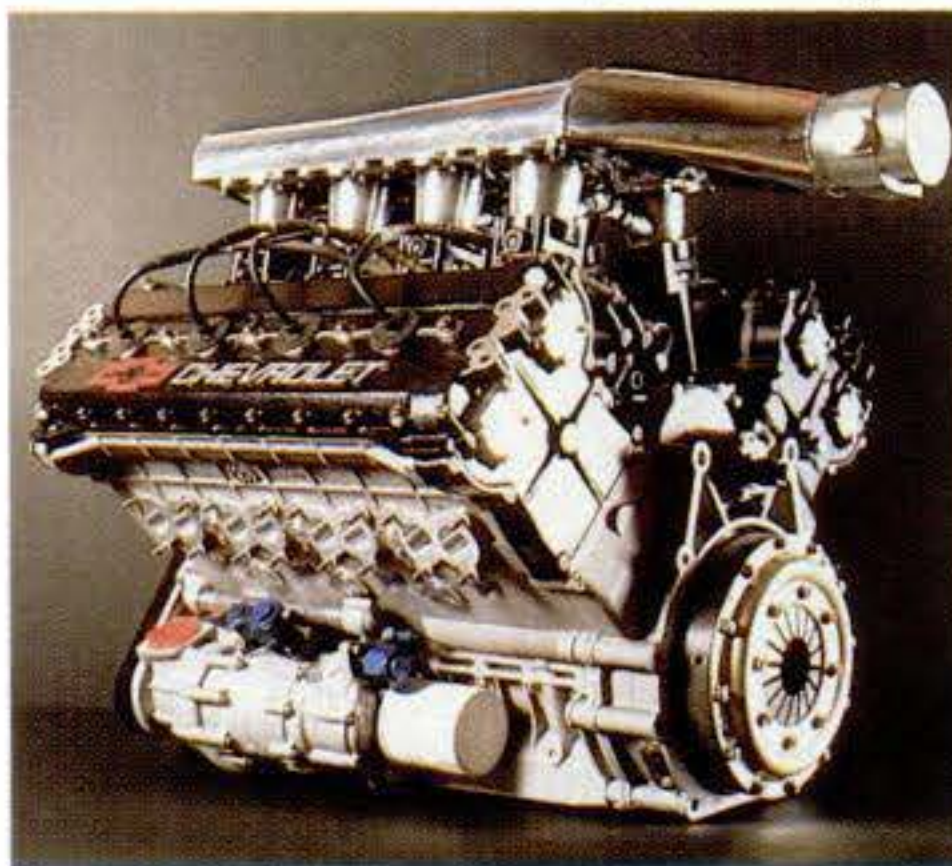
Driving Trans Sport

Give the steering wheel of Pontiac's Trans Sport a twist. The rim moves as expected. But the center hub, which carries a display of switches reminiscent of a high-line stereo, remains motionless as planetary gears transmit the steering motion to the wheels.

Straight ahead, apparently floating over the road, is a hologram showing such basics as vehicle speed and engine rpm. The display, which manages to look both translucent and solid at the same time, allows one to read the gauges without taking one's eyes off the road. The hologram hasn't been without its problems, though. Says Marvin J. Fisher of the General Mo-

tors design staff, "We had the projection too far out in front, and it would run into walls."

The Trans Sport van is the latest in a series of high-visibility concept vehicles from GM that serve as showcases for new technology. But unlike other dream cars, Trans Sport



Reality and fantasy: The engine's real; the Corvette Indy, only for show.



PHOTO BY GREG SHARKO

bears a close resemblance to vehicles GM plans to build in the future.

Meanwhile, Trans Sport shows off some of the far-out features being considered for production. The bulbous glass bubble covers a cockpit that includes a passenger-side personal computer. A TV camera and monitor replace the rearview mirror, while a range finder and digital display tell exactly how closely the gawkers are following.

The bubble canopy will be replaced by a more conventional windshield, and some of the electronics may not see production. But insiders say the shape of Trans Sport hints at the styling for a new GM mini-van. Under its plastic skin will be a steel-cage structure similar to that of the current Fiero.

Chevy at Indy

Chevrolet, which once kept its racing efforts in the shadows, is now trying to elbow its way into the biggest spotlight of them all. Along with Penske Racing and England's Ilmor Engineering, Chevy has developed a specially built engine for Indy car racing. The 2.65-liter turbocharged V8 will be a bolt-in replacement for the Cosworth V8 currently used by most teams. Penske will try the Chevy engine first, and hopes to have the bugs out in time for this year's Indy 500. Later, the engine will be for sale to any team that can afford one.

To add a little fantasy to the gritty reality of racing, Chevy dropped the engine into its latest show car, the Corvette Indy. The mid-engine two-seater features four-wheel drive, electronic suspension, four-wheel steering, and computerized traction control.

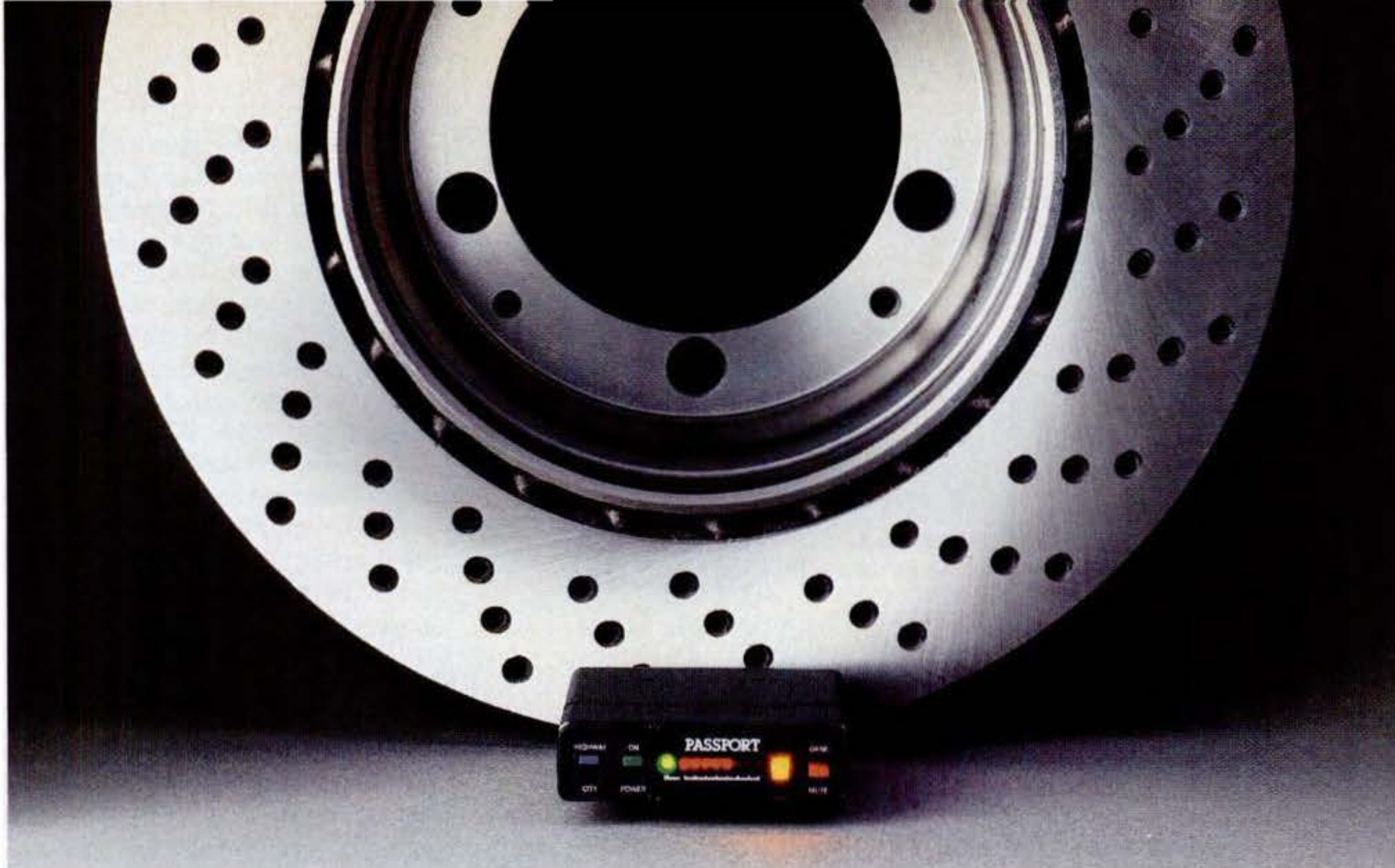
Chevrolet won't actually build a road-going version of the Indy engine, however. The racing hardware is just too expensive for mass production, say Chevy engineers.

Traction control

Daimler-Benz, which has historically viewed semiconductors with suspicion, has now come forth with a burst of electronic activity. Three different electronic traction-control systems will be offered during 1986 on various Mercedes models in Europe. Depending on customer acceptance, the systems may find their way onto U.S.-bound cars.

The simplest system is an electronic limited-slip differential. The same wheel-speed sensors used for the anti-lock brakes tell a computer when a

Continued



Small Wonder

It's here, *pocket-size* radar protection.

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Small means nearly-invisible protection

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This miniaturization is possible only with SMDs (Surface Mounted Devices), micro-electronics common in satellites but unprecedented in radar detectors. It's no surprise that such a superlative design should be greeted by superlatives from the experts.

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The experts report excellent performance. Simply switch PASSPORT on and adjust the volume knob. Upon radar contact, the alert lamp glows and the variable-pulse audio

Small means the size of a cassette tape

begins a slow warning: "beep" for X band radar, "brap" for K band. Simultaneously a bar graph of Hewlett-Packard LEDs shows radar proximity.

As you get closer, the pulse quickens and the bar graph lengthens. Should you want to defeat the audible warning during a long radar encounter, a special switch provides silence, yet leaves PASSPORT fully armed for the next encounter. A photocell adjusts alert lamp brightness to the light level in your car. PASSPORT was designed for your protection *and* your convenience.



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The Pontiac Grand Prix will be one version of GM's new mid-size car for 1988.

rear wheel starts to spin, and the computer activates a hydraulic solenoid that locks the differential.

The next step up is acceleration skid control. Again, wheel-speed sensors are used to detect loss of traction. But here the computer pulses the brake on the spinning wheel, transferring torque to the wheel that still has grip. If both wheels start spinning, an electronically controlled throttle on the engine reduces power until traction is restored.

Most sophisticated is the 4Matic automatic four-wheel drive. The mechanical pieces are similar to other four-wheel-drive systems, with a transfer case behind the transmission and separate differentials front and rear.

With 4Matic, the various parts of the system are activated depending on the amount of wheelspin. First four-wheel drive is engaged, then the center differential is locked. Finally, for maximum traction, the rear differential also locks.

Mercedes engineers say the advantages of all three electronic systems include smooth operation with anti-lock brakes, and the need for minimum decision making on the part of the driver.

1988 Grand Prix

The Pontiac Grand Prix shown above will be just one of the models resulting from the new GM 10 program. Front-drive cars developed in this program will replace the current A-bodies as well as the current rear-wheel-drive G-bodies (Grand Prix, Monte Carlo, et al.). The GM 10s will square off against the Ford Taurus and Mercury Sable, as well as against new mid-size cars due from Chrysler.

Mule teams

Far removed from the spit-shined plastic mock-ups that are trucked from car show to car show are the hard working mules—cars that camouflage

advanced engineering under a body cobbled together from existing sheet metal. Development engineers in Detroit produce some strange-looking mules. We recently saw a 1988 Ford Thunderbird sporting a rear section from a 1985 Camaro. And a much modified Cavalier recently spotted at the General Motors tech center hid the steering and suspension for the 1989 Camaro.

Horsepower is easier to hide, and GM sends mules out into the night to test a variety of experimental engines. One of the most interesting is an aluminum 3.2-liter V6 being considered for the 1989 Camaro/Firebird. The engine has either three or four valves per cylinder, port fuel injection, and distributorless ignition. At 200 horsepower, it has the punch to replace most current V8s.

Buying British

General Motors recently bought a majority share of Britain's Lotus Group, and the Corvette may be one of the first to benefit. Chances are that the next Corvette will be equipped with the Lotus active suspension, which uses electronics and hydraulics to replace springs, shocks, and anti-roll bars. There also have been reports that Lotus will develop a V8 engine for the Corvette.

Toyota owns a 22 percent share of Lotus, making it another likely customer for Lotus technology. Lotus also does work on contract for other car makers, and it is currently working on a 16-valve cylinder head for Chrysler. GM has said it will allow Lotus to continue to operate independently.

Chrysler engines

Chrysler's Lotus-designed 16-valve cylinder head is just one of a series of advanced projects the company has on the drawing board.

Maserati will build a complete 16-valve engine, based on the current

Chrysler 2.2, for use in the Chrysler-Maserati sports car. Bare blocks will be shipped to Italy, and Maserati will supply the rest of the hardware.

Chrysler is also working on a 200-horsepower version of its turbo 2.2. The engine will debut in a four-wheel-drive version of the Laser/Daytona. The company also plans to go ahead with an all-new V6, to be built in a U.S. plant. Previously that project had been deferred in favor of a three-liter V6 to be supplied by Mitsubishi. It appears now the Chrysler engine will be slightly larger than the Mitsubishi and will go into bigger cars.

News briefs

- Hot items from the Society of Automotive Engineers show in Detroit: Polimotor and Amoco are building a plastic V6 engine for Indianapolis racing... Kyocera Corp. showed a turbocharged diesel with ceramic pistons, cylinders, and heads. The engine uses no cooling system or radiator... The plastic wheel that's been under development by Motor Wheel Corp. will go into production for the 1987 model year... Britain's Lucas Industries proposes a 48-volt electrical system for passenger cars. A combined starter/alternator and multiplexing would help make the system lighter and more efficient than present 12-volt systems.

- The high-dollar Rover XX, to be introduced in the U.S. market in 1987, will be called the Sterling. The car will use the same Honda 2.5-liter V6 engine as in the Acura Legend [PS, Feb.].

- Both BMW and Jaguar will offer reconditioned used cars with 12-month, 12,000-mile warranties. The programs are intended to provide entry-level cars to lure new buyers into the stable.

- The Ford Scorpio, named Car of the Year in Europe, will go on sale here this fall as a Merkur. A 2.9-liter engine and anti-lock brakes will be standard. Ford hopes to sell 10,000 to 15,000 Scorpions per year. So far, the Merkur brand hasn't set the world afire. Only about 9,000 XR4Ti's were sold in 1985.

- The EXP was once the ugliest car in the land. Now Ford has restyled it, adding an Escort-style nose with flush lights. It's still not pretty, but at least it won't frighten the children. Sport and luxury versions will be available, and prices start at \$7,186. **PS**

Contributors: Jack Keebler (New York), Dan McCosh (Detroit), Jim Scheffer (West Coast), David Scott (Europe), Tom Wilkinson (New York)



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Only Dodge Backs Every Truck It Builds With 5/50 Protection, Standard. We have so much confidence in the quality of the trucks we build, we back them with the same warranty we give the cars we build. With our standard 5 year or 50,000 mile Protection Plan.* Nobody else...not Ford, not Chevy, not the imports... does that. When we say we build tough trucks, we prove it.

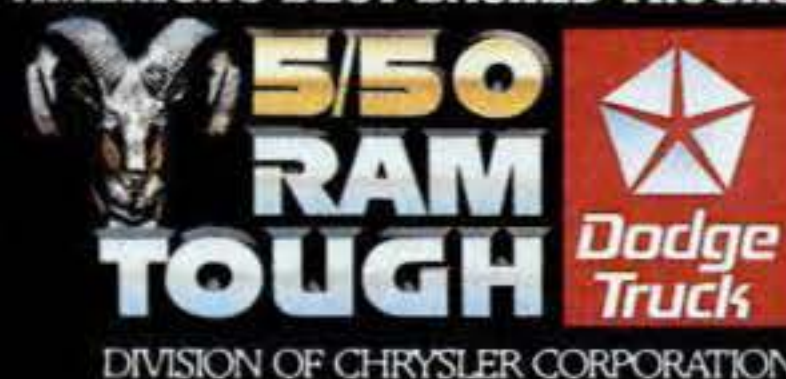
There's something about the way it sits on the road that tells you this one isn't going to leave

you hoping for more. A look that's straight, direct, unshakable. The name is Dodge.

[†]Shown with dealer installed options.

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U.S. Family Sedans

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The old and the new (clockwise from top): the Mercury Grand Marquis, Oldsmobile Delta 88, and Buick LeSabre Custom.

POPULAR SCIENCE CAR TEST #206

Total cars tested to date: 743

Big, old-fashioned rear-drive sedans are making a strong sales comeback. Why? To find out, POPULAR SCIENCE revisited the rear-drive Mercury Grand Marquis and was impressed by its roominess, silence, smooth ride, and powerful V8. The latest in big-car technology, General Motors' Oldsmobile and Buick front-drives provide a revealing comparison.

By JACK KEEBLER

Photos by Greg Sharko

Like rolling living rooms, big sedans of past decades powerfully, quietly, and smoothly transported a generation of American families around the block and across the continent. These land yachts provided spacious six-person roominess, pillow-soft seating, cavernous trunk space, and rocket-quick acceleration with 400+ cubic-inch V8s.

But they were fuel thirsty. And when oil prices soared, many large families

switched to smaller, lighter front-drive sedans or mini-vans. What drivers found were better parking-lot maneuverability, tighter elbow room, surer handling, a stiffer ride, and less of their budget bitten by the gas pumps. Now, with the stabilization of fuel prices, many families are rediscovering the attributes—and deficiencies—of the large old-style rear-drive sedans.

This test pits the old against the new. It is *not* simply a contest between rear drive and front drive. What we are observing in this sedan square-off is the cumulative effect of modern design

technology on the family sedan. This technology includes taut European-style suspension designs, small high-output engines, lightweight unit-body construction, and, in this instance, front drive. Modern rear-drives that incorporate all of these technologies compete headlight to headlight with the best front-drives. That's obvious from the high-performance four-door-sedan test PS ran last December. Rear-drive, front-drive, and all-wheel-drive designs competed, and the differences in performance were small.

Continued

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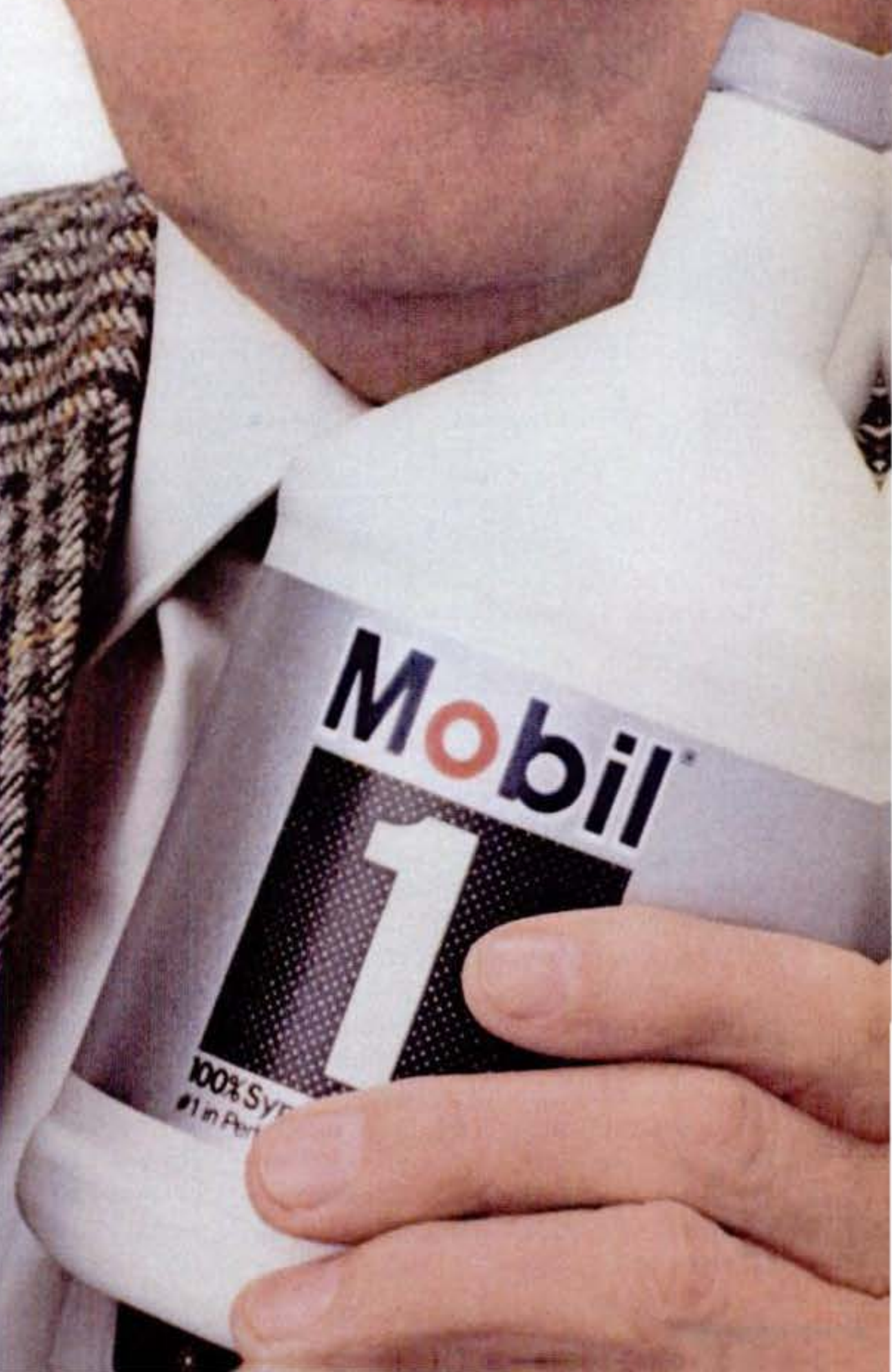
*Based on average price for Mobil 1 and Havoline as reported by NPD-Auto Facts.



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The Mercury Grand Marquis scrubs its rubber through the low-speed test.



The Olds Delta 88 swoops through the handling course with top marks.



The Buick LeSabre Custom drops its sleek nose as it enters the brake lane.

Engineers in Detroit, with the facts before them and faced with the challenge of equalling rear drive's interior quiet and smooth ride in front-drive designs, are actually debating what they might accomplish with modern engines, lightweight materials, new aerodynamics technology, and a switch back to rear-drive chassis configurations.

To explore this old-style-sedan versus modern-sedan technology question, PS pitted Mercury's traditional rear-drive Grand Marquis against General Motors' newest front-wheel-drive family sedans: the Buick LeSabre Custom and Oldsmobile Delta 88 Royale Brougham.

A time machine could take you back to an era when automobiles were extra wide and long and provided ample comfort for six adults. Or you could just take a ride in a 1986 Mercury Grand Marquis. Hardly anything has changed. Our tan Merc had a huge trunk that effortlessly swallowed our large test-equipment box. Inside, the bench seats comfortably accommodate six passengers. In a crunch, eight slim and friendly riders could squeeze onto the seats.

Despite the sleeker sheet metal, state-of-the-art power trains, and more precise European-style suspension systems, it's as if time stood still inside the GM models, too. Soft headlin-

PS ratings— test report in a nutshell

The ratings are based on test results and measurements. Results should be read with the understanding that they reflect tests only on our sample cars. An excellent rating is 5 points; very good, 4; good, 3; fair, 2; poor, 1; very poor, 0.

	Buick LeSabre Custom	Mercury Grand Marquis	Oldsmobile Delta 88
Acceleration	5	5	5
Braking	2	1	2
Handling	5	2	5
Maneuverability	5	3	5
Quietness	4	5	3
Roominess	4	5	4
Vision	4	4	4
Entry/exit ease	3	4	3
EPA economy	3	3	3
Ride comfort*	3	4	2

*Author's opinion

ing of red velour-like material, a lack of instrumentation, fake chrome trim, and spongy seats made me remember that dark time before the auto-company engineers snatched Detroit back from the marketers and stylists.

On the plus side, and despite their greatly reduced exterior dimensions, the GM models give up just fractions of an inch on most interior dimensions. Head room is actually greater in the Oldsmobile and Buick sedans. And, being front-drives, they have no transmission hump.

V8 versus V6

The Mercury had the biggest engine, with a sequential fuel-injection V8. (Sequential injection times each of the eight injectors to deliver fuel pulses coinciding with the opening of its corresponding intake valve. Less sophisticated injection systems fire fuel at the back of the intake valve even when it's closed.) Coupled to a marvelously quiet and smooth-shifting four-speed automatic, the powerful longitudinally mounted V8 is an absolute gem of silent, vibration-free power. With wheels spinning just slightly, the V8 hauled the Marquis' monstrous chassis up to 60 mph in just 12 seconds. That's not bad for a body-on-frame antique that's just a few hundred pounds shy of two tons. And my around-town fuel economy was about 17 mpg—close to the EPA's 18-mpg city estimate.

Both the Buick and Olds were fitted with a Buick-built 3.8-liter sequential fuel-injection V6. Like the V8 in the Merc, the V6s were also coupled to four-speed automatics. Almost as smooth as the Ford V8 in most driving modes, the transverse V6s were at times slightly rougher and significantly noisier (confirmed by our decibel readings; see test results).

Continued

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Family sedans *Continued*

During acceleration the V6s roared strongly. And although I rather enjoyed their rich bass note, it would probably be more appropriate in a sports coupe. At stoplights, the steering wheels in both GM unit-body sedans vibrated visibly, and seemingly uneven firing

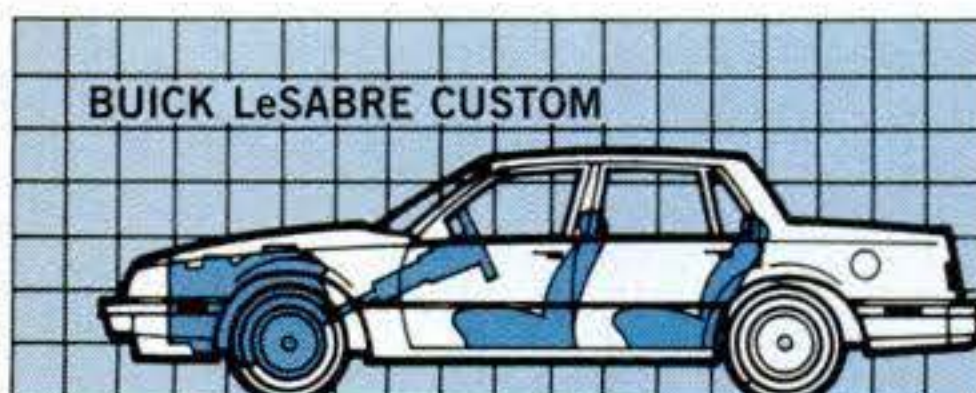
pulses could be felt through the seats and pedals.

The Buick V6 provides a healthy wallop of torque. Off the line the two front-drives surged ahead eagerly and instantly. And too much throttle easily spun the unloaded front tires (typ-

ical of powerful engines in a front-drive chassis). The LeSabre's 10.7-second run to 60 mph was 1.3 seconds quicker than that of the Grand Marquis. The 88 posted a slightly slower 11.2-second time. This may have been due to an engine valve lifter gone sour. By the

Continued

DRAWINGS BY RUSSELL VON SAUERS



1 GRID BLOCK = 1 SQ. FT.

POPULAR SCIENCE TEST RESULTS

	Buick LeSabre Custom	Mercury Grand Marquis	Oldsmobile Delta 88 Royale Brougham
TEST RESULTS			
Acceleration (sec.)			
0-30 mph	3.59	3.89	3.65
0-40 mph	5.25	5.90	5.37
0-50 mph	7.51	8.55	7.88
0-60 mph	10.70	12.00	11.20
Brake test (cool) 60-0 mph			
Stopping distance (ft.)	192	184	168
Pedal pressure (lbs.)	40	8	22
Brake test (hot) 60-0 mph			
Stopping distance (ft.)	182	206	178
Pedal pressure (lbs.)	40	13	20
Interior noise @ 60 mph (dBA)	63	57	66
Handling test (mph)	67.1	60.0	71.2
Maneuverability test (mph)	29.7	25.7	31.1
EPA FUEL MILEAGE (mpg)			
Highway	30	26	30
City	19	18	19

TEST CONDITIONS Ambient temperature, 45° F; relative humidity, 90%; barometric pressure, 30.2 in. Hg

Dimensions and specs

DIMENSIONS (inches)

Wheelbase	110.8	114.3	110.8
Overall length	196.4	214.0	196.1
Overall height	55.4	55.2	55.5
Overall width	72.4	77.5	72.1
Track, F/R	60.3/59.8	62.2/62.0	60.3/59.8
Ground clearance	6.7	5.2	6.7
Front head room	38.9	37.9	38.9
Front hip room	55.5	57.6	55.5
Front leg room	42.4	43.5	42.3
Rear head room	38.3	37.2	38.3
Rear hip room	56.1	56.9	56.1
Rear leg room (min.)	38.3	39.3	38.6
Rear knee room (min.)	2.8	—	2.8
Coupe distance	34.3	34.0	34.3

SPECIFICATIONS

Engine type	V6	V8	V6
Displacement (cu. in./L)	231/3.8	302/5.0	231/3.8
Compression ratio	8.5	8.9	8.5
Carburetion	E.F.I.	E.F.I.	E.F.I.
Net hp @ rpm	150 @ 4,400	160 @ 3,600	150 @ 4,400
Net torque (ft.-lbs.) @ rpm	200 @ 2,200	280 @ 2,200	200 @ 2,000
Transmission	4-speed automatic	4-speed automatic	4-speed automatic
Axle ratio	2.73	2.73	2.73
Tire make	General	Goodyear	Goodyear
Tire type	Ameriway XT	Polysteel radial	Eagle GT
Tire size	P205/75R14	P205/75R15	P215/65R15
Steering	Power, rack and pinion	Power, recirculating ball	Power, rack and pinion
Overall steering ratio	18.4:1	16.4:1	17.4:1
Turns, lock to lock	3.13	3.40	3.13
Turn diameter (ft.)	39.7	39.1	39.7
Front suspension	MacPherson strut, coil springs	Independent, short and long arm, coil springs	MacPherson strut, coil springs
Rear suspension	Independent strut, coil springs	Four-bar link, coil springs	Independent strut, coil springs
Front stabilizer-bar diameter (in.)	1.18	1.00	1.25
Rear stabilizer-bar diameter (in.)	0.62	—	0.62
Brakes	Disc-drum	Disc-drum	Disc-drum
Brake swept area (sq. in.)	278.3	385.8	278.3
Fuel tank (gal.)	18	18	18
Trunk space (cu. ft.)	16.1	22.4	16.1
Liftover height (in.)	32.7	29.4	32.7
Curb weight (lbs.)	3,172	3,818	3,190
F/R weight distribution (%)	64/36	56/44	63/37
Basic price	\$12,511	\$13,504	\$13,461
Price as tested*	\$14,665 ¹	\$15,920 ²	\$16,893 ³

Major options (over \$100): ¹ETRAM-FM stereo cassette (UX1) \$494, 3.8 SF1 V6 \$370, aluminum wheels \$255, electric door locks \$180, cruise control \$175, cloth interior \$133, concert speakers system \$125, tilt wheel \$115; ²A/C \$762, six-way power driver's seat \$237, power locks \$228, wire wheel covers \$176, speed control \$176, rear-window defroster \$145, convenience group \$134, tilt steering wheel \$115; ³six-way power seats \$450, FE3 handling package \$408, power windows \$270, cruise control \$175, 55/45 dual-control seats \$133, electronic A/C control \$125, electric mirrors \$116

*Destination and delivery charges not included

PS serviceability ratings

How easy is it to service these cars? To give you an approximation of how difficult it is for a typical person to perform various service operations, we examine each test vehicle. The numbers mean: 1, very difficult; 2, difficult; 3, average degree of difficulty; 4, easy; 5, very easy.

	Buick LeSabre Custom	Mercury Grand Marquis	Oldsmobile Delta 88
CHECKING FLUIDS			
Battery	5	5	5
Master cylinder	5	3	5
Windshield washer	5	5	5
Engine oil	5	4	5
Coolant	5	4	5
CHECKING THE ENGINE			
Spark plugs	4	2	3
Distributor	n.a.	3	n.a.
Oil filter	5	3	3
Oil fill	5	5	5
REPLACING HOSES			
Upper radiator hose	5	5	5
Lower radiator hose	5	3	5
Heater hoses	2	2	3
CHANGING BULBS			
Headlights	3	3	3
Taillights	4	2	4
Front running lights	4	3	3
Front parking lights	4	3	3
Front directionals	4	3	3
Rear directionals	4	3	3
Rear running lights	4	—	4
CHECKING FUSES			
	2	3	5
CHANGING SPARE TIRE			
	3	3	3
CHANGING BELTS			
	4	4	5

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We'll bet the first thing our customers will tell you is that ESCORT works. It finds all kinds of radar: X band, K band, over hills, around curves, moving mode, instant-on ambush. Whatever the trap, ESCORT finds it. And this long-range detection is followed up with a full report on the radar's strength. You can read this report on the analog meter. You can hear this report on the audio warning, pulsing slowly when the radar is weak, quicker as it strengthens, then constant as you approach range.

ESCORT even uses a separate warning tone for the two radar frequencies, "beep" for X band, "brap" for K band. The two radars behave differently. Trust ESCORT to keep you informed.

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end of the test, the 88's engine was tapping softly but ominously. And when the Olds finally limped into New York City, the rap was echoing strongly off the buildings on narrow streets.

Soft-ride trade-offs

The Marquis reminded me a bit of a sensory deprivation chamber on four wheels. In fact, the lack of speed and road-surface information can be spooky. Lulled into driving too fast on a wet cobblestone street in Manhattan, I attempted to brake and turn at the same time. The result was a near-silent slide toward the side of a parked car. Fortunately, I was able to catch the adrenal-squeezing drift at the last second. A front-drive engine's weight over the drive wheels might have helped me control the slide more easily.

As I expected, the softly sprung Grand Marquis was significantly slower than the taut GM front-drives through both the high-speed lane-change maneuver and the low-speed maneuverability grid. What I didn't anticipate were the Merc's long stopping distances. Around town the brakes bit well. And during the test there was virtually no recorded fade, even after 10 warm-up stops from 60 mph. But the higher weight of the body-on-frame construction and an old-

fashioned narrow tire footprint worked against the Marquis in the brake lane.

Nose to nose, there isn't much difference between the LeSabre and 88. That's why it was such a revelation to drive these cars with their different suspensions. The Buick was fitted with the smooth-riding base suspension. The Olds was equipped with the high-performance FE3 suspension. The effect of the two suspensions on the performance and character of these look-alikes is remarkable.

The Buick suspension felt well damped and smooth. And although not as smooth as the Marquis', it gives up little in dynamic performance to the performance suspension in the Olds. Considering the generally poor state of public roads in the New York area, this seemed to be a fine compromise between the marshmallow ride in the Merc and the too taut ride in the Olds. One dynamic area that did seem compromised by the base suspension was braking. The Buick's cold stop was eight feet longer than the Marquis' long 184-foot effort. As with the Marquis, the narrow and less grippy tire that comes with a soft-ride suspension may have played an important role in the longer stopping distances.

The Olds FE3 suspension package's high-rate springs, restricted shock

valving, larger sway bar, and wider, stickier tires virtually ensured that the 88 would win top honors in the handling and maneuverability trials. I think, however, that this truly harsh setup will win few friends with family-sedan buyers. My wife, who was nine months pregnant, refused to travel in the car after a single short trip.

With hot or cold brakes, the Olds managed to stop far shorter and with greater stability than the Marquis or LeSabre. Again, the performance tire that comes with the FE3 package probably provided extra grip.

Author's choice

For those who remember 65-mph speed limits, Sunday afternoon drives with the entire family, and trunks that hold enough luggage for three-week vacations, nothing but the Mercury Grand Marquis will suffice. But the traditional lack of ride control and nonsupportive seats scared me off. The Olds 88 and the Buick LeSabre are practically twins. The only reason I'd choose the Buick over the Olds 88 is its softer ride. The optional Olds FE3 handling package seems excessively harsh for a family sedan. Equip the two GM models with the same springs, shocks, and sway bars, and I probably couldn't make a choice.

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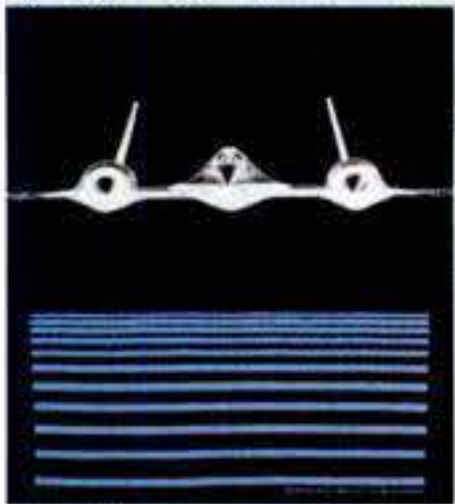
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F-15 EAGLE



F-16 TACTICAL FIGHTER



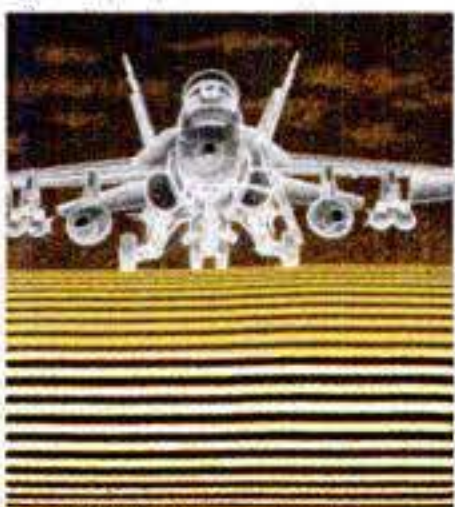
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AH-64 APACHE



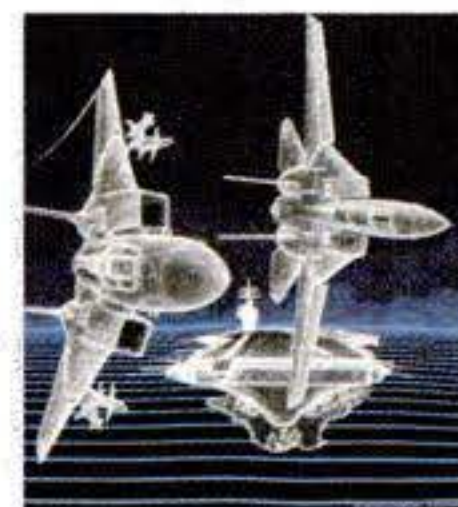
F-20 TIGERSHARK



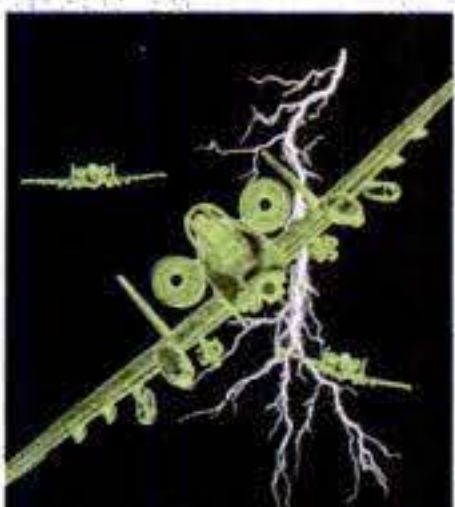
F-18 HORNET



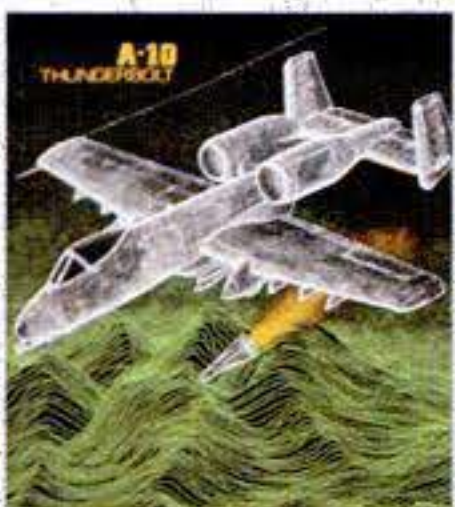
F-4 TACTICAL FIGHTER/BOMBER



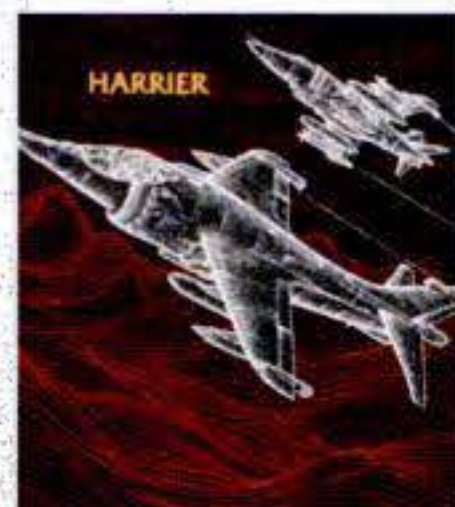
F-14 TOMCAT



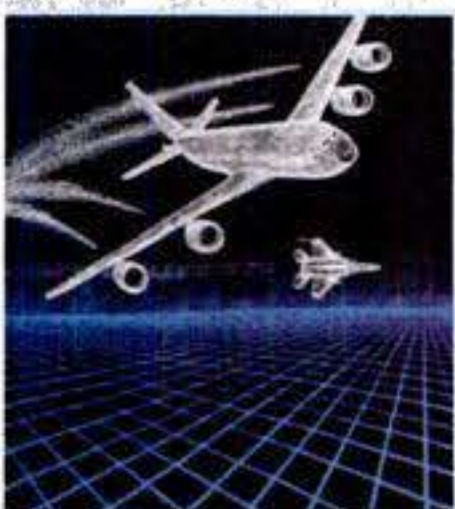
A-10 THUNDERBOLT



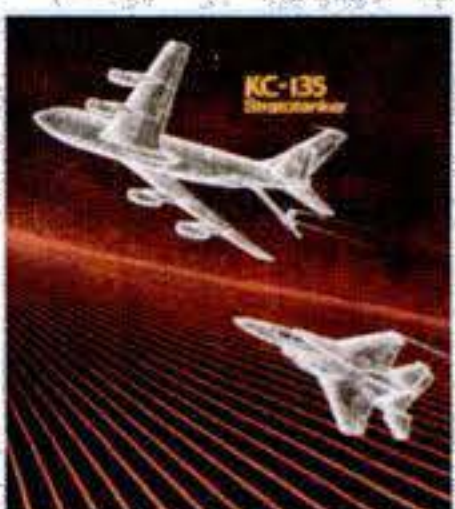
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(actual shirt photos)

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Electronics Newsfront

By WILLIAM J. HAWKINS



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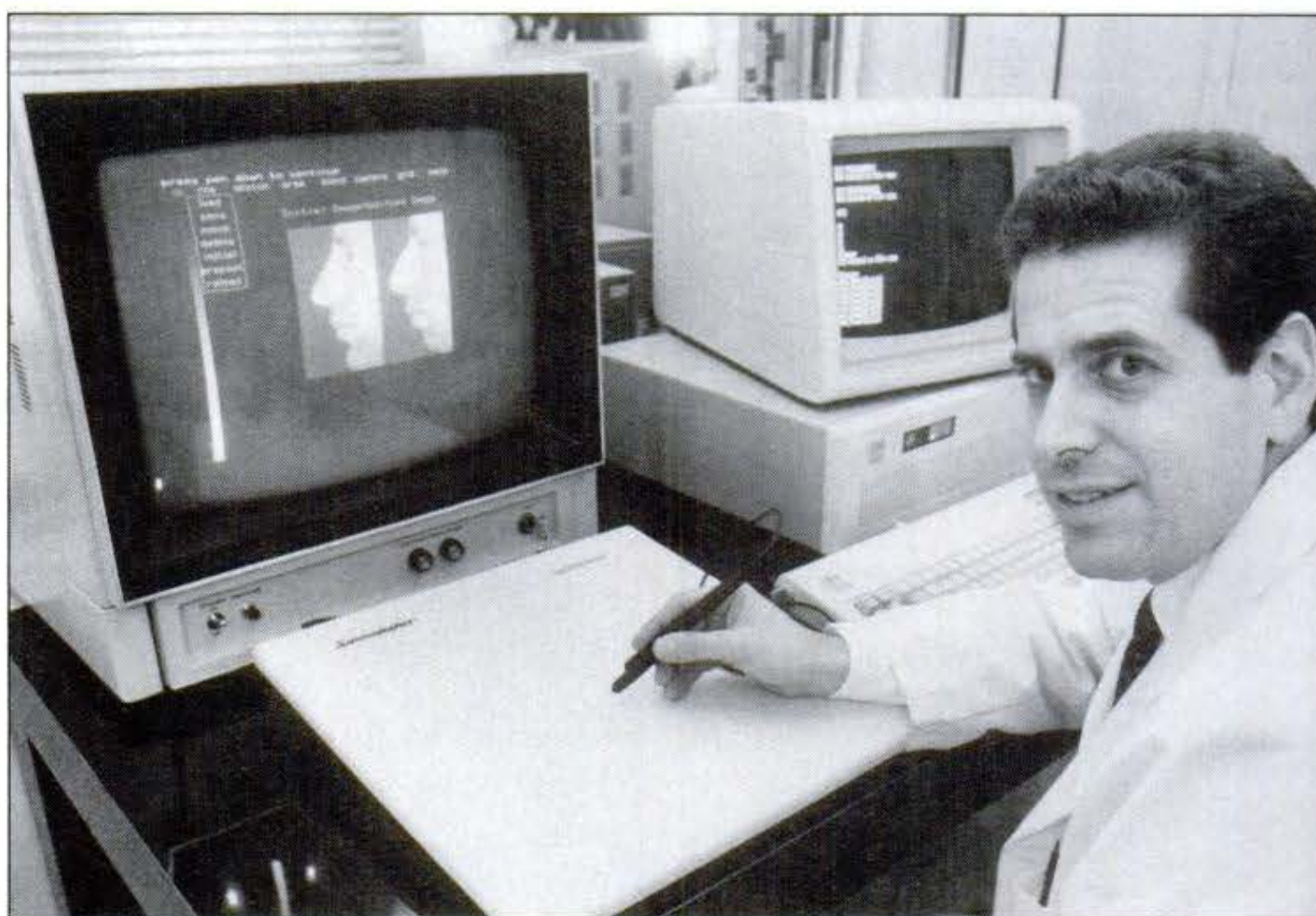
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Split screen shows present (right) and future face. Which nose do you like?

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Smile... click... a video image of your face appears on the screen. Very nice, except, well, the nose could be a little straighter, the chin a bit tighter, that mole should come off, and maybe the loss of a few years would help. No problem: The Imager, from Face Systems (548 Broadway, New York, N.Y. 10012), will take care of all that.

"People can now see instant simulations of cosmetic surgery," says Nancy Burson, originator of the Imager, one the newest electronic tools for plastic surgeons. The system includes a video camera, high-resolution monitor, graphics tablet, and software for an IBM AT computer.

"In the past, doctors stood patients in front of mirrors and merely discussed changes," says Burson, "or they took pictures of a patient and retouched the photos. Now that's changed."

With the Imager, a patient sits in front of the video camera and is photographed. The image is held in memory and displayed on the screen. At the press of keyboard buttons, the *before* picture is electronically cropped to size and moved to one side of the screen.

Working with the graphics tablet, the doctor indicates where changes are to be made. The computer then cre-

ates an *after* picture, based on the changes, by adding or removing flesh and changing the facial features. For example, if the skin shown in the original image is tightened, lines and wrinkles are removed in the *after* picture. "A patient gets to see a side-by-side comparison instantly," says Burson.

Multiple pictures can also be taken for views at various angles. Those views and each change made to them can be stored on disk for future recall.

Critics point out that this type of electronic mirror could allow doctors to show more than they can produce. But proponents, such as New York user Dr. Elliot Jacobs (above) and Burson, see it as an important tool. "A doctor will strive for what's on the



Word processor has a touch screen.

screen," says Burson. "The Imager is simply a visual tool that allows better communication with the patient."

Chinese word processor

To create a word in the English language, you just select the right combination of letters from a 26-letter alphabet. But in the Chinese language there is no alphabet. Each word is a distinct character—a picture—that's created by the correct placement of individual lines. And because there are more than 10,000 unique characters in the Chinese language, it has presented an unwieldy problem for creating documents with a word processor. Presently, special keyboards are used that allow an operator to enter the individual segments needed to create a character. It's a slow process that requires extensive training, according to Intech Systems (6901 W. 110th St., Minneapolis, Minn. 55438), makers of a new touch-screen Chinese word processor.

With the Intech system, a user creates a character in a three-step process by pointing to Roman letters on the screen that represent the character's sound (see photo). On the initial touch, the system displays the matching syllables; on the next touch, all matching Chinese characters are displayed. Finally, the operator touches the character that represents the exact meaning required, and it is entered into the document.

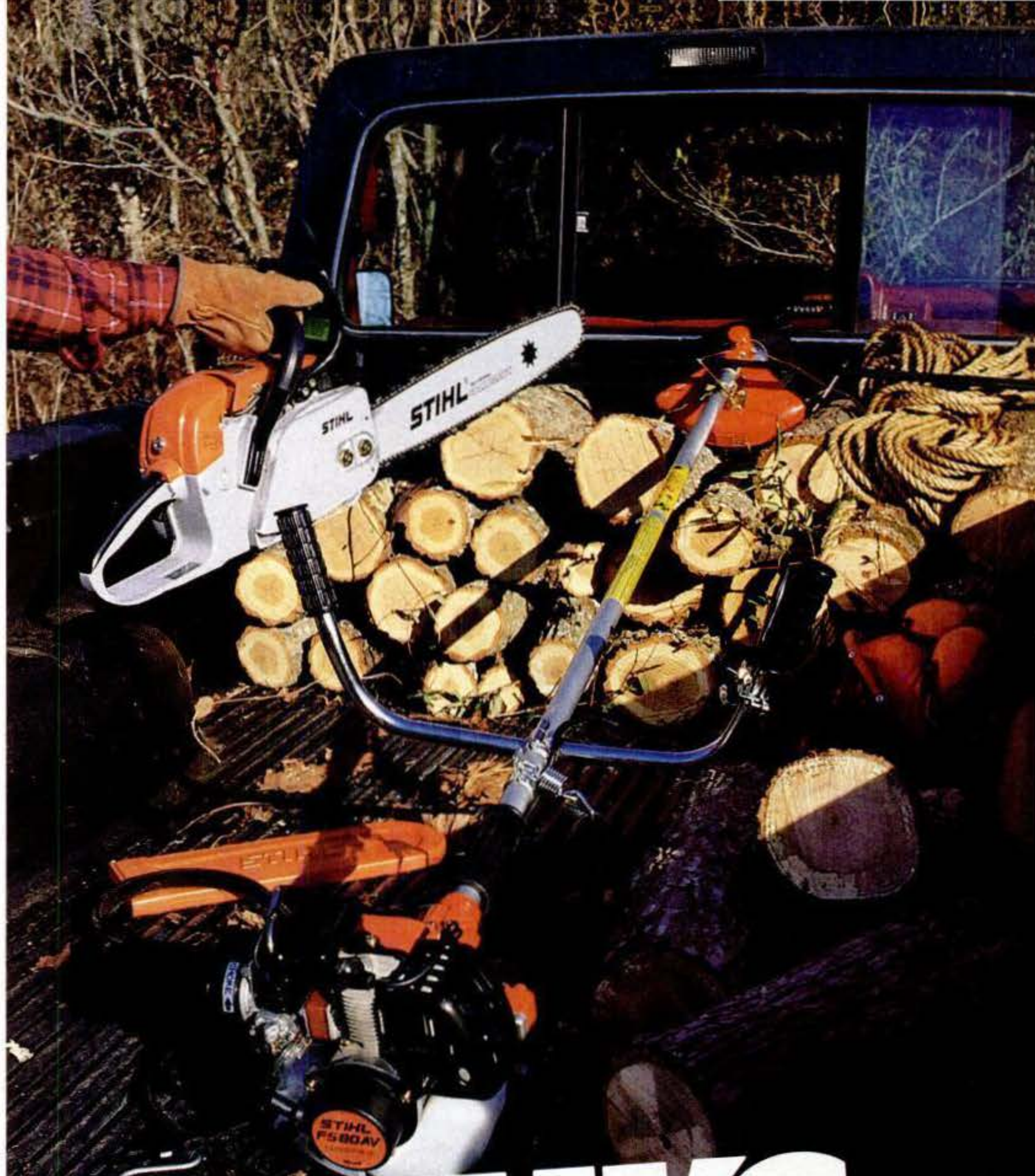
The system allows up to 13,000 Chinese characters to be processed and printed in either the traditional right-to-left, top-to-bottom format or in the left-to-right format. Price: \$5,000.

Smart chip

Expert-system software allows a computer to think like a human expert. The system uses human knowledge stored as rules to solve a problem ["Expert Systems," PS, March]. Now researchers at AT&T Bell Labs have put an expert system on an integrated-circuit chip. Because the software and rules are permanently stored in the single device, the chip is fast. It can make 80,000 logical inferences a second. That means it gives advice 10,000 times faster than a conventional computer programmed with expert-system software.

Normally, an expert system contains hundreds of rules, depending on the application and its level of competence; but the AT&T experimental device contains only 16 rules. To make it "smart," the rules are based on an

Continued



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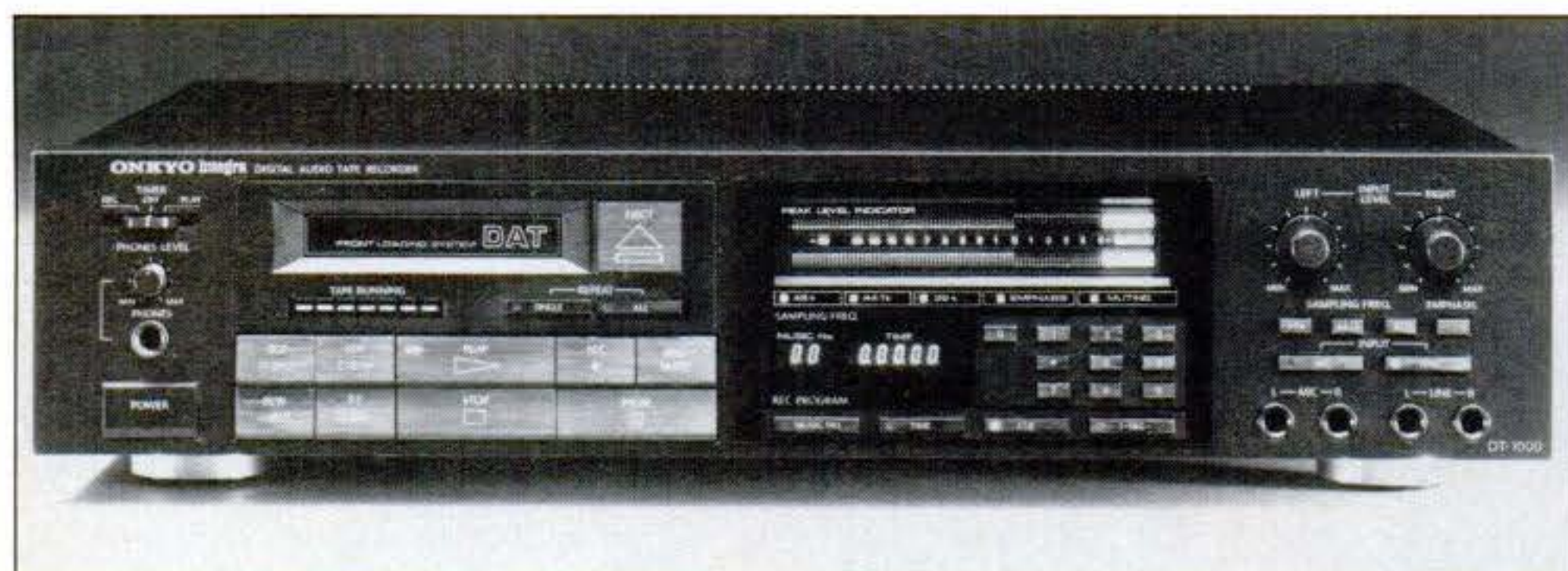
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Perfect reproduction: Onkyo's prototype DAT records and plays back audio.

area of artificial intelligence called fuzzy logic. With this, traditional true or false rules are not used. Instead, the chip deals with possible or probable conditions, and draws conclusions.

Where could it be used? One place may be in the cockpit of a fighter plane. The Air Force's Wright Aeronautical Laboratory is now working on a Threat Expert Analysis System. Designed to replace radar warning receivers, the expert system warns a pilot of a potential enemy and recommends the appropriate action... *fast*.

DATs are coming

Although many companies are working on digital audio tape recorders (DATs) for the home, only Onkyo has shown a prototype (photo). Because it records music as computerized bits and bytes that represent sound, the playback on a DAT is virtually identical to the original recording. The problems that plague conventional analog recorders—tape hiss, dropouts, limited frequency response, and dynamic range—no longer exist. The price of a DAT, at first, is likely to be about \$800, but models won't be available until at least the end of this year.

Quick looks

- If you've turned on your backyard dish expecting to get HBO or Cinemax and got a scrambled signal instead, remember PS warned you some time ago. But take heart: You can buy a decoder from HBO (Direct Broadcast Department, 1100 Avenue of the Americas, New York, N.Y. 10036). It's \$395, plus \$13 a month for receiving HBO or Cinemax; \$20 for both.

- Attach the serial or parallel interface connection on your computer to GridComm's (20 Old Ridgebury Rd., Danbury, Conn. 06810) GC-1400 communications box, then plug the box into a wall outlet. Result: The \$549 unit uses the AC line as a network connection, and your computer can communicate with up to 32 similarly equipped computers. Two other devices—a \$449 attachment for a printer and a \$799 modem—can be added. Data exchange rate: 19,200 baud.

- The camcorder-format war [PS, April] is getting hotter: JVC has introduced a new \$1,495 VHS-C model that uses the extended-play speed to record up to an hour on one cassette instead of the usual 20 minutes. The 2.9-pound unit uses a 1/2-inch charge-coupled-device imager for a low-light sensitivity of 15 lux. **PS**

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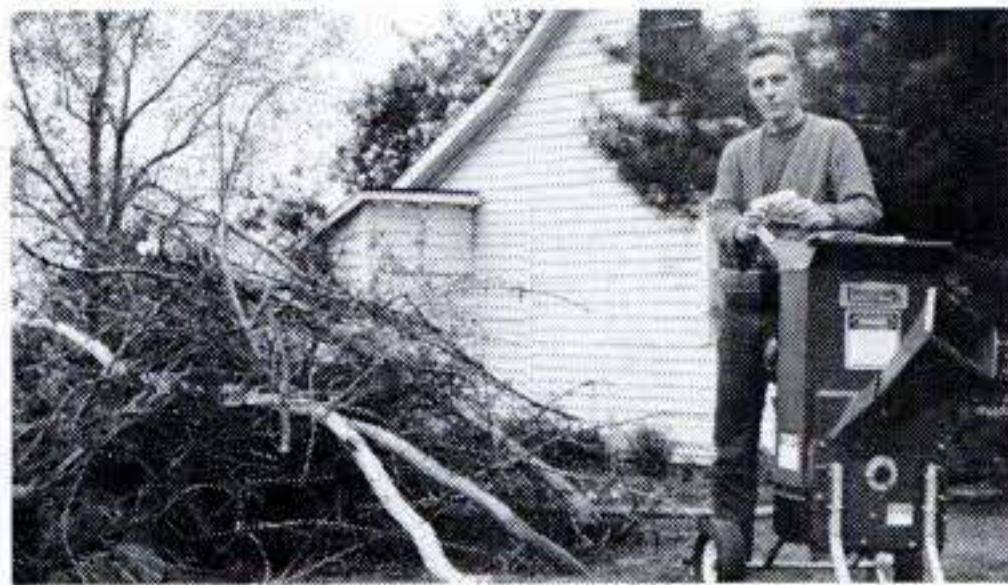
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3 13

Airport X-ray spots invisible weapons

A new security device can detect concealed terrorist weapons, such as plastic handguns and explosives, that were previously invisible to X-ray baggage-inspection machines. The improved X-ray unit can locate other hidden items, such as contraband narcotics, foodstuffs, and gemstones.

By STEVEN ASHLEY

Alarm swept through the international community of airport security experts when word arrived that Libyan strongman Col. Muammar al Qadhafi was buying hundreds of *largely plastic* handguns from an Austrian gunsmith. The worry was that Libyan-backed terrorists might have a much easier time smuggling the lightweight Glock 17 pistol—a so-called Hijacker's Special with its detachable metal barrel, slide, and spring—past X-ray baggage-inspection devices and metal detectors at airports. Perhaps even more disturbing were earlier comments by gun experts like Andy Molchon, president of the National Association of Federally Licensed Firearms Dealers: "The American plastic gun will shortly make its appearance... [however] the American model will be 100 percent plastic."

Happily, security specialists now have some reason to feel reassured, because a Cambridge, Mass., research company, American Science & Engineering (AS&E), has "developed a new method of seeing those plastic guns we've been hearing about in the news," says the firm's president, Dr. Martin Annis.

"Our Model Z X-ray inspection machine can select for materials, such as plastic, that have a low atomic weight, or what we call low Z." That means, he says, that the new system can, in addition, locate plastic explosives and plastic knives, smuggled narcotics (cocaine and heroin), and gemstones (diamonds), as well as contraband

foodstuffs (tropical fruits and Polish sausages), concealed in carry-on airline luggage.

Annis says that demonstrations of the \$70,000 Model Z X-ray inspection system (about twice the cost of a conventional airport X-ray machine) have impressed security personnel from the U.S. military, the Federal Aviation Administration, and the Customs and Agricultural Departments, as well as

lected from consecutive sweeps by two different-energy X-ray beams can be processed by a computer so that objects composed of a specific atomic element can be located in an X-ray image. Annis realized that his company's own proprietary X-ray technology could perform a similar function by distinguishing and displaying low-atomic-weight (low-Z) materials like plastics in radiographic images.

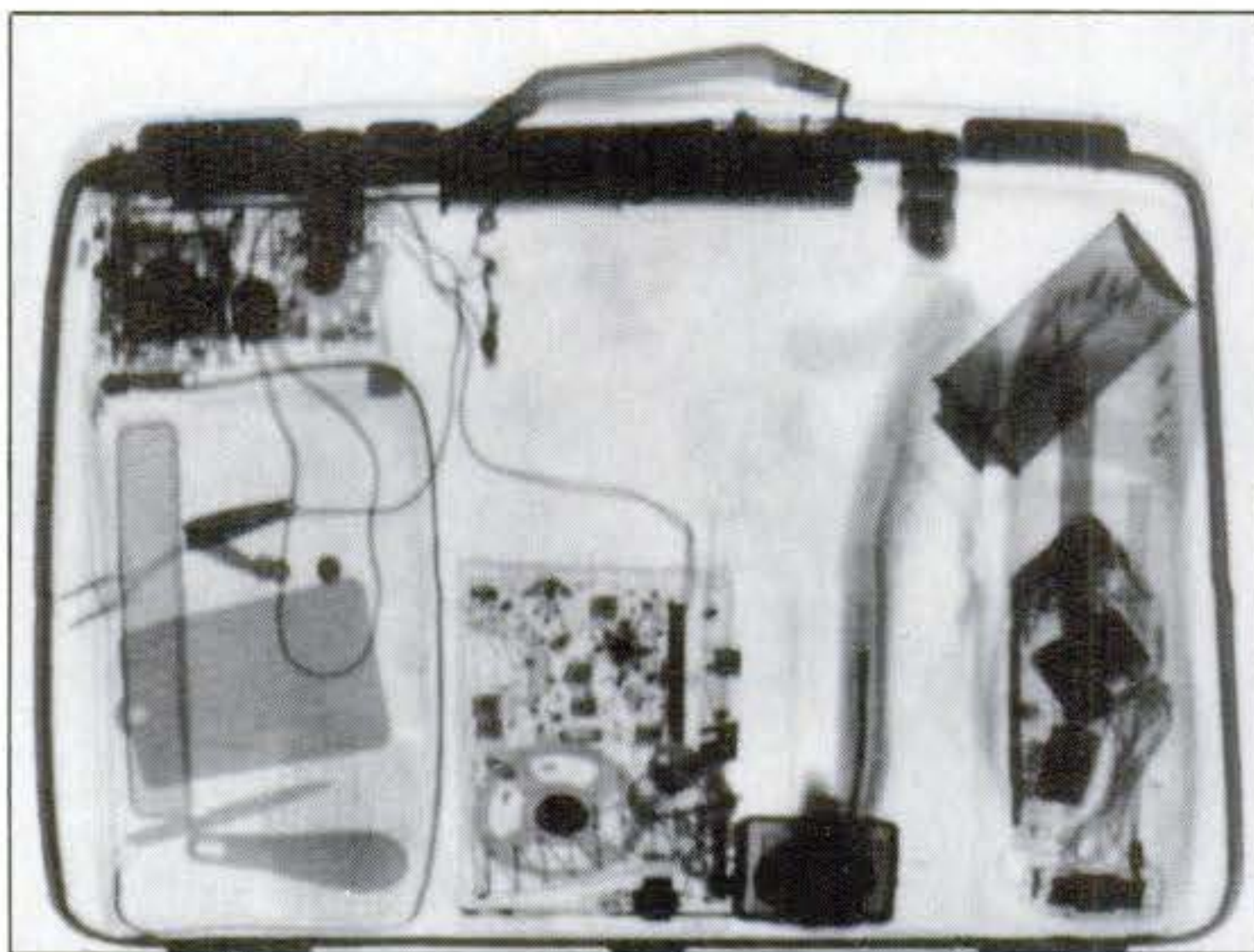
Annis knew that AS&E's patented low-dose flying-spot technology for X-rays—a pencil beam of radiation that rapidly scans an object—would allow an X-ray detector to form a video image of the X-rays that are scattered off-line by low-Z atoms. Creating an image of the scattered radiation would be impossible with a conventional X-ray machine, Annis says, because the fanlike spray of X-rays emitted by these devices would result in a fogged image. With a fan beam, scattered radiation comes from all points on the object at once, making a mess of the backscatter image. When the flying-spot beam illuminates an object, the scattered X-rays that are detected at any time are known to have originated from the particular region of the object the device is spotlighting. The Model Z's processor

can then collect these spot samples to form a video-image mosaic in the same way the beam flying across a TV screen creates the picture.

The Model Z simultaneously displays a conventional X-ray shadowgraph image showing high-Z materials, such as metals, and the new image de-

Continued

**CAN YOU FIND THE GUN IN THIS X-RAY?
TURN PAGE FOR ANSWER**



This conventional airport security X-ray of a suitcase shows an umbrella, travel case, portable radio, electric razor, and shoes, among other items. The bag also contains a disassembled Glock 17 pistol—a handgun made largely of plastic, which makes it transparent to conventional X-ray devices.

airline representatives. Tests are now underway, he adds.

The concept for the device arose, Annis explains, when he was considering security applications for another advanced X-ray technique called dual-energy radiography ["Can Technology Stop Terror in the Air?" PS, Nov. '85]. In dual-energy X-ray devices, data col-

A SPA IS A SPA IS A SPA?

A CONSUMER GUIDE

If you've been considering a spa or hot tub you're probably already aware of the benefits and pleasures of whirlpool massage. However, not all spas and hot tubs are alike. The true test of any spa is whether it can provide these pleasures conveniently and efficiently. We'd like you to know what to look for when shopping for a spa and show you why the engineers who designed the HOT SPRING SPA have produced the best one available today.

1. MATERIALS AND CONSTRUCTION.

The HOT SPRING SPA is made of the most advanced and durable material of any spa—ROVEL™. This high-impact plastic is superior to wood of old fashioned hot tubs because it doesn't absorb water, leak or deteriorate. Unlike fiberglass or acrylic surfaces, ROVEL won't peel, blister, crack or delaminate. Check the warranties of other spas and you'll see that ROVEL is guaranteed to be much more durable than any other spa material. In fact, a recent industry trend has seen many acrylic manufacturers reduce surface warranties to just one year! ROVEL is softly textured so you won't slip when entering or exiting the spa.

2. CONVENIENCE AND EFFICIENCY.

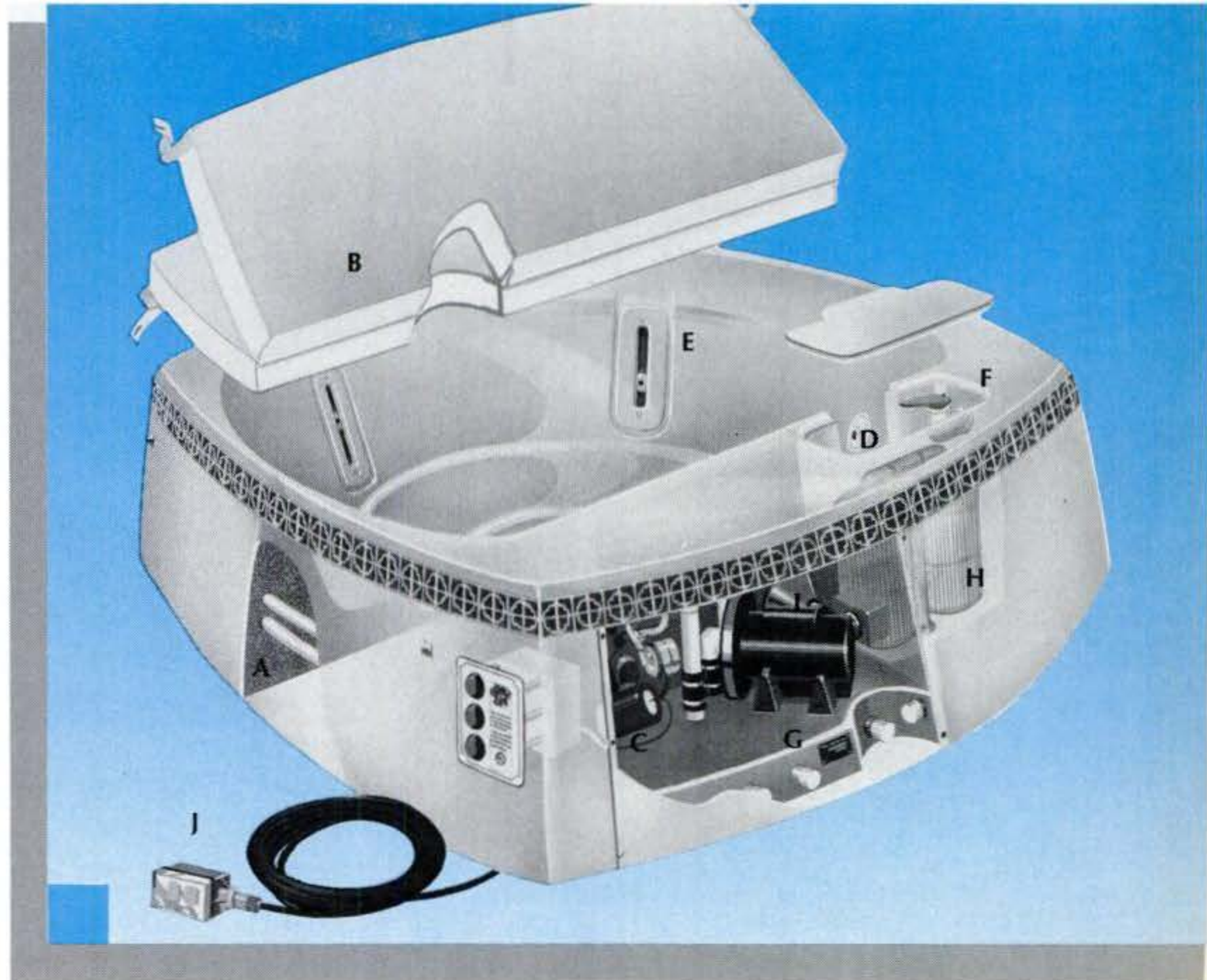
Most spas and hot tubs have very little thermal insulation, some have none at all! Just how important is insulation? It's the most important feature in private spa ownership! Uninsulated spas will physically not operate outdoors in colder climates, making spa use as seasonal as a swimming pool. Further, a marginally insulated spa forces the heater to run continuously, costing you money. The HOT SPRING SPA is FILLED SOLID with over 130 lbs. of polyurethane foam insulation (A) and standard equipment includes a 3½" thick insulating cover (B). This heavy insulation makes it economical to keep the HOT SPRING SPA heated to your desired temperature 24 hours a day, regardless of location. You can use your HOT SPRING SPA at any time day or night, in any weather, and for just pennies.

3. TEMPERATURE.

Precise temperature control is important. A spa should control temperatures within $\pm 1^\circ\text{F}$. or you'll forever be too hot or too cold as the water changes temperature. The HOT SPRING SPA achieves this accuracy by using a "precise demand" thermostat with its sensor in intimate contact with the water (C).

4. HYDROTHERAPY JETS.

Vigorous jet action is the key to true hydrotherapy. Only the HOT SPRING SPA gives you the option of powerful fixed jets (22 psi at each jet) (D), and the unique massaging effects of MOTO-MASSAGE™. The exclusive MOTO-MASSAGE (U.S. Patent #4,523,340) glides gently up and then down the entire length of your back in a continuous sweeping motion that simulates the natural stroking of a manual massage (E). In addition, we provide an air control which can be reached from inside the spa so you can vary the intensity of the jets (F). These features combined with the STA-RITE Max-E-Glas pump provide the best hydrotherapy available today (G).



5. WATER CHEMISTRY AND FILTRATION.

Most portable spas contain less than 180 gallons of water. It is difficult to maintain proper chemistry in such a small body of water. Therefore it is necessary to drain them more frequently than the HOT SPRING SPA which contains 275 gallons. Good filtration is essential in any spa, but in other portables, it has been overlooked. The HOT SPRING SPA has the largest capacity filter of any portable spa—50 square feet (H). It requires attention only 2 or 3 times a year. Its top-loading design allows you to inspect, remove, and clean it without draining the spa.

6. LIGHT FOR NIGHTTIME USE.

Another feature of the HOT SPRING SPA is the underwater light (I). It's dimmer controlled so it's never too bright or too dim, and different colored bulbs can be used for different effects.

7. NO INSTALLATION.

Simplicity of installation should be checked. An in-ground spa is the most difficult, usually requiring backyard excavation, building permits and an expensive installation crew. Hot tubs are not much simpler. The HOT SPRING SPA avoids these problems by requiring only common household current to operate (110v. 20amp.) (J). There is no permanent hard wire electrical hook-up, no external plumbing to assemble, and no building permits to obtain. As a portable appliance, the HOT SPRING SPA will not increase your property taxes and you can take it with you when you move.

8. LISTED BY UNDERWRITERS LABORATORIES.

The HOT SPRING SPA is completely listed by Underwriters Laboratories, the recognized experts in testing for safety. The importance of

correct and safe electrical design should not be overlooked. Check for the U.L. Mark on the outside of any spa you're considering—you'll see it on the HOT SPRING SPA.

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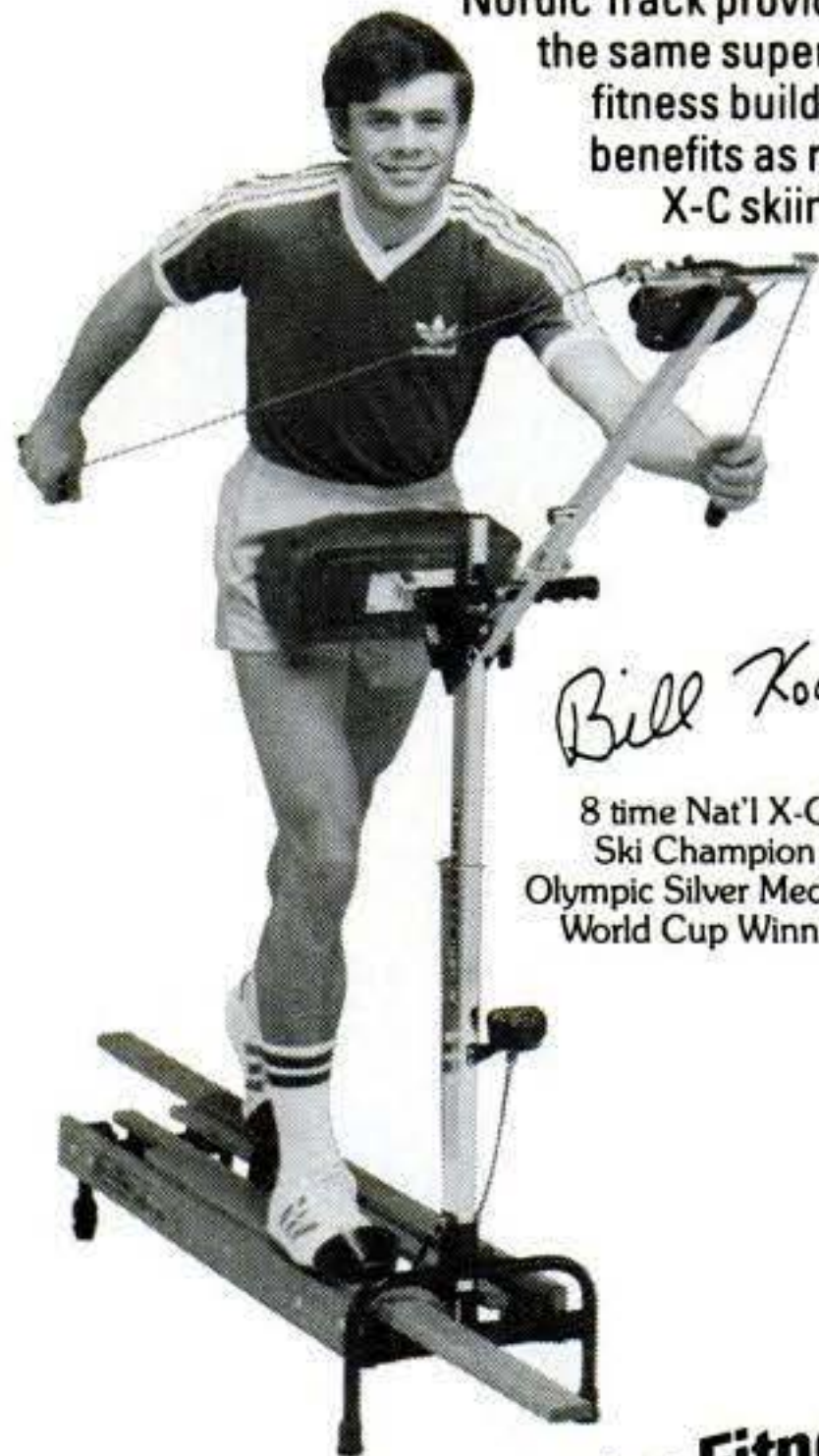


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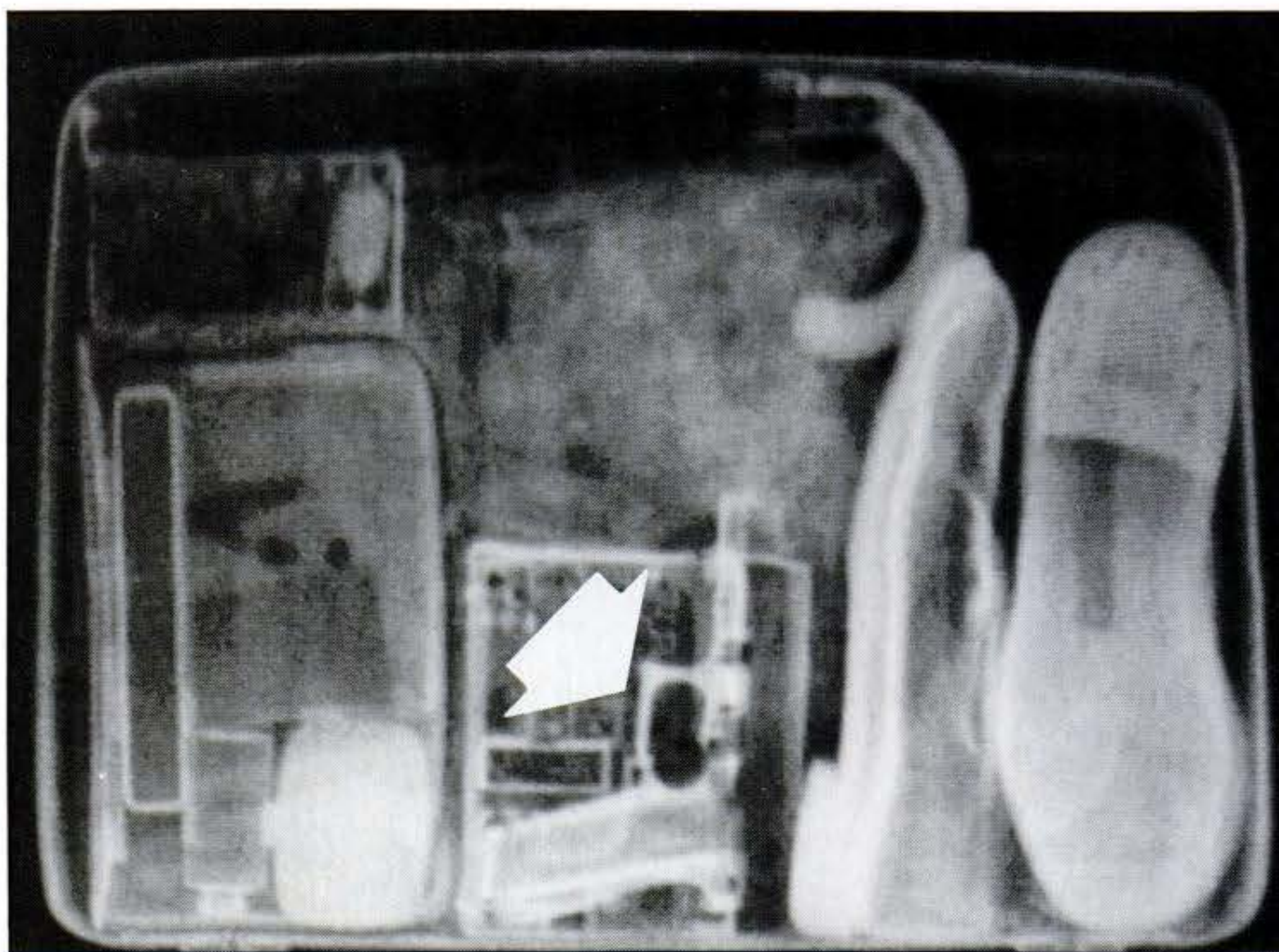
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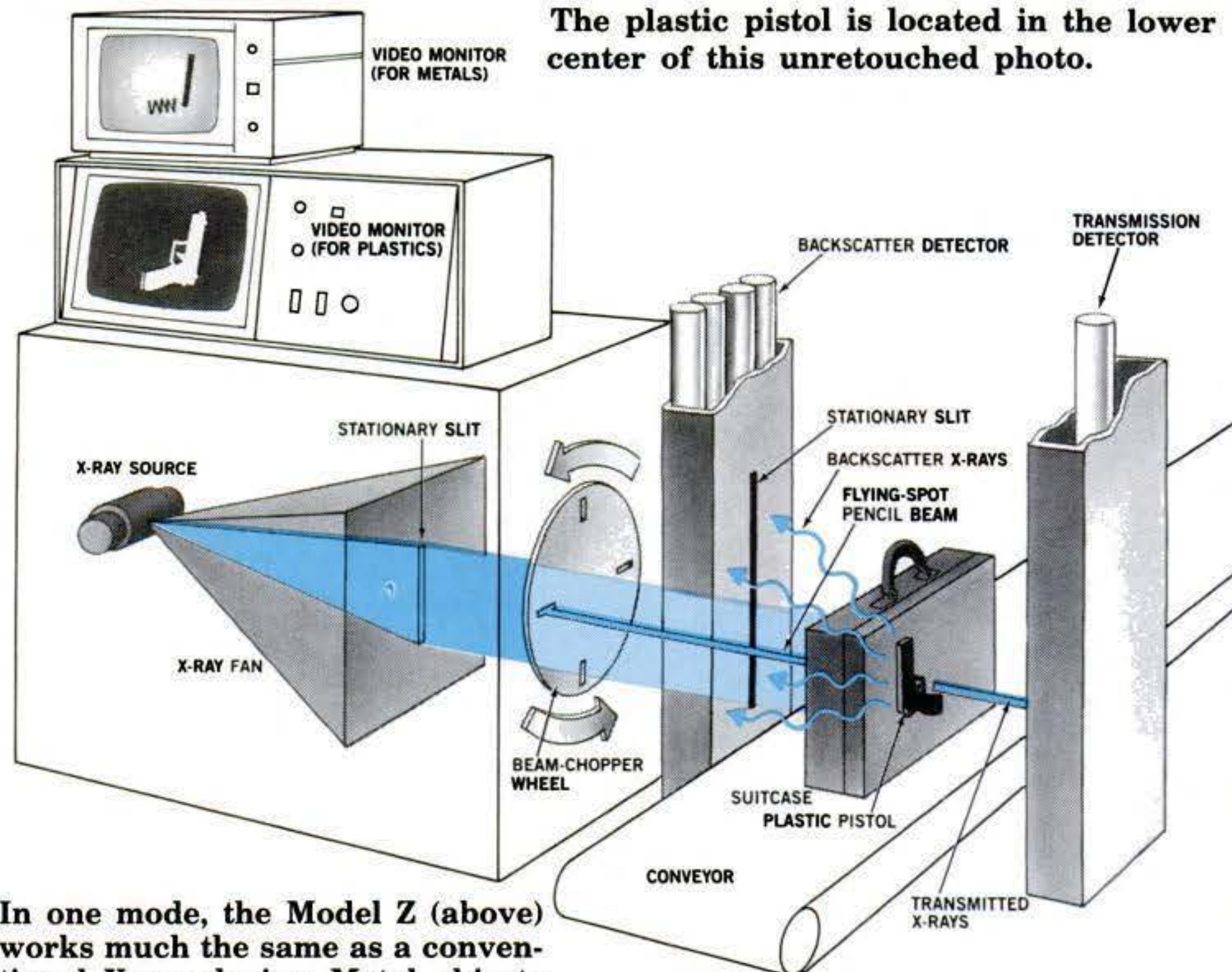
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Airport X-ray *Continued*

WHERE'S THE GUN?

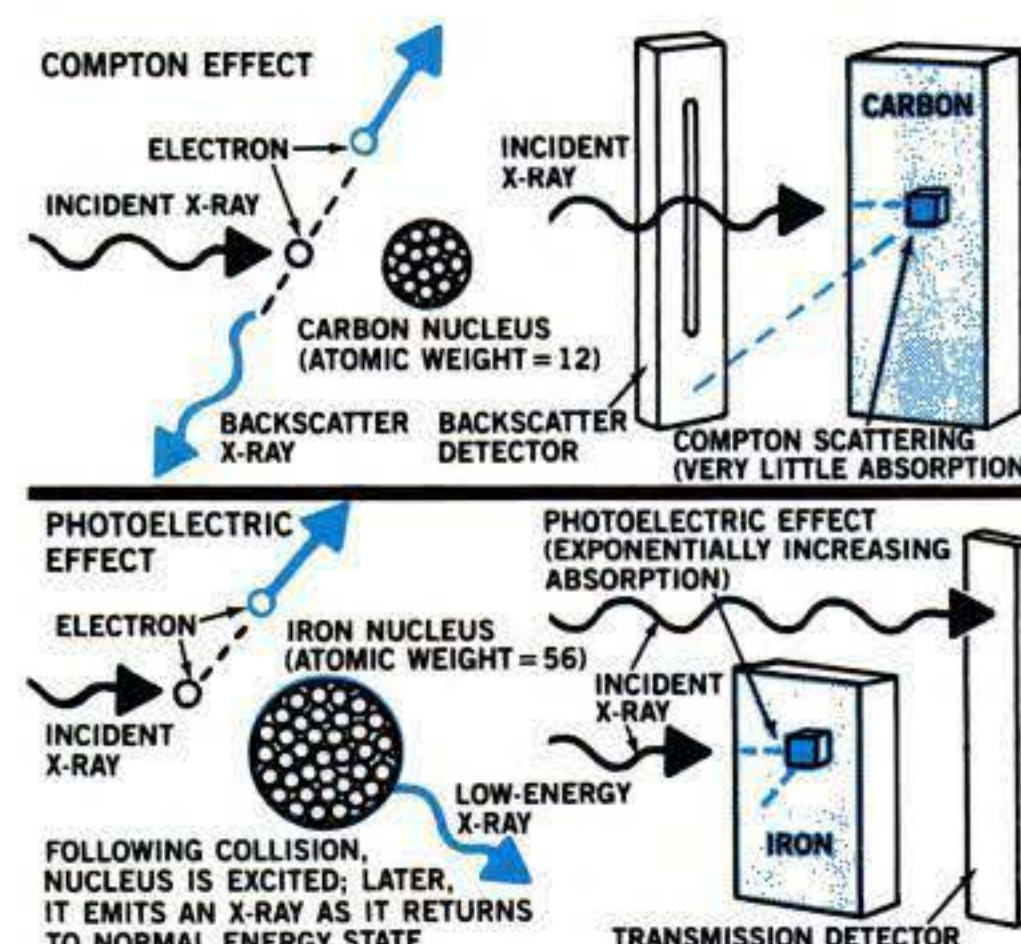


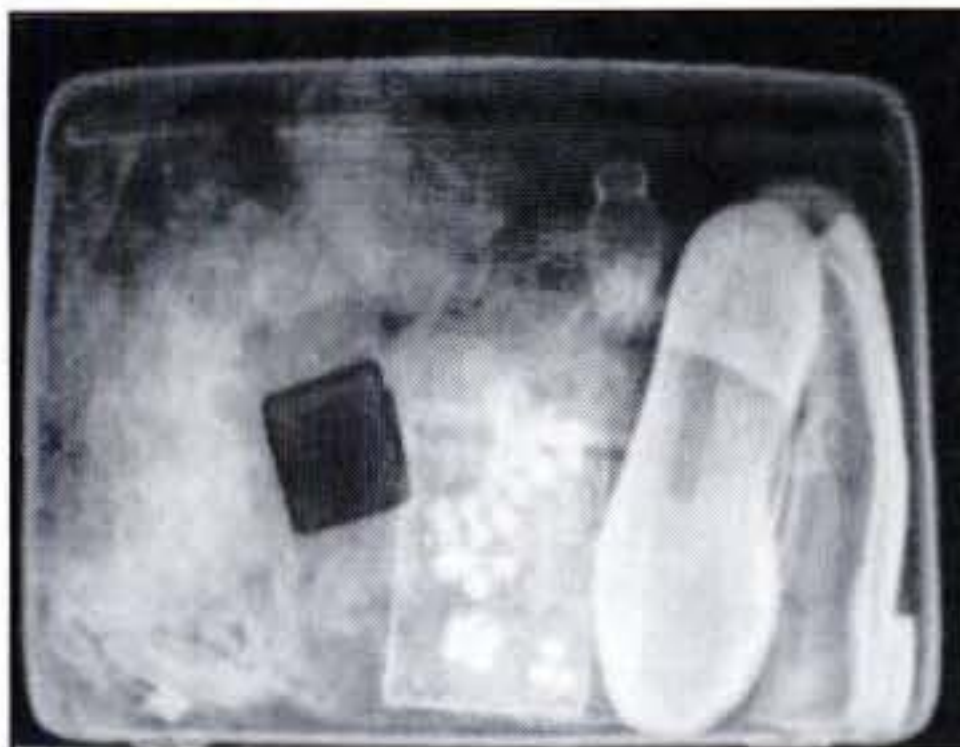
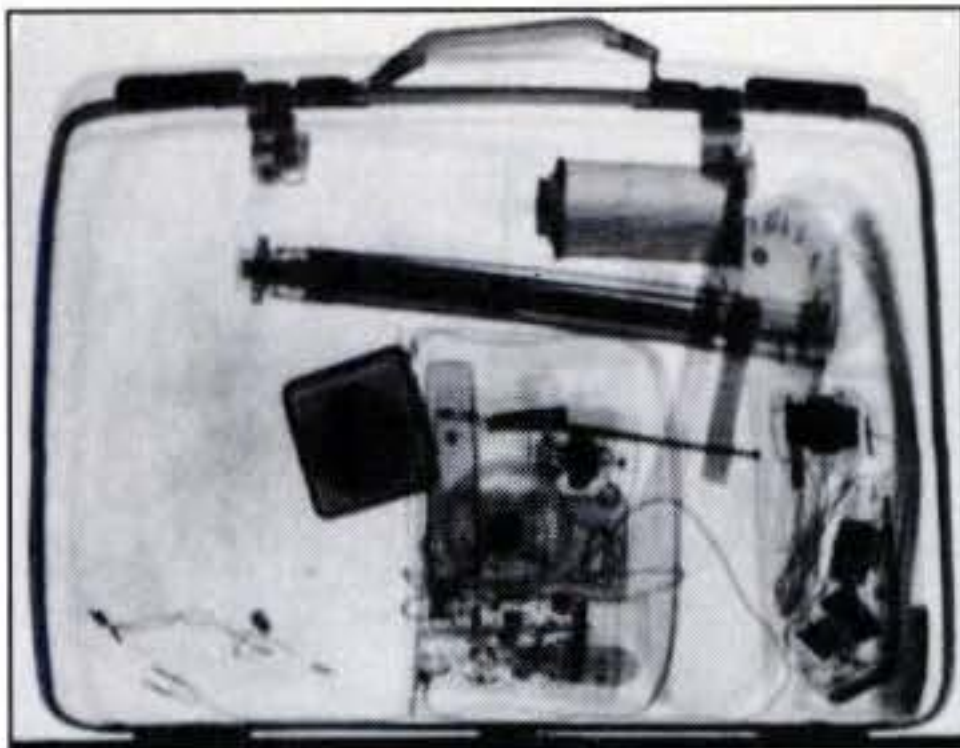
The plastic pistol is located in the lower center of this unretouched photo.



In one mode, the Model Z (above) works much the same as a conventional X-ray device: Metal objects stop X-rays from passing through, creating a silhouette footprint registered by the rear detector. The forward detector records X-rays that have been scattered back by low-atomic-weight (low-density) materials like plastics. Flying-spot technology, a means by which a stationary slit, a chopper wheel, and a moving conveyor combine to produce a pencil-thin X-ray beam that scans an object, allows the capture of backscatter data. A security guard would monitor both images. The collisions between X-rays and atoms (right) explain the physical interactions that create the backscatter and transmission X-ray images.

DRAWING BY DAN OSYCZKA





At top is a conventional X-ray of a suitcase containing an aerosol can, alarm clock, shoes, umbrella, radio, electric razor, clothes, and a bunch of grapes—the latter listed as contraband by the U.S. Department of Agriculture as a possible carrier of farm pests such as the Mediterranean fruit fly. The grapes appear as white circles in the lower center of the Model Z X-ray (bottom).

picting low-Z materials. "We tell the observer that if you see something in the Z-image that glows white, it means that the object backscatters X-rays and is therefore a low-Z material," explains Richard W. Sesnewicz, AS&E marketing manager for imaging systems. "The observer then has to say to himself: Do I recognize that white shape as being usual or unusual when compared with visual information provided by the conventional X-ray image? For instance, if I notice a white blob in what the conventional X-ray tells me is a radio, I have to determine whether that's normal."

"Of course," Annis notes, "it is possible to use computer pattern-recognition techniques to filter out standard shapes so as to automate this process, but it's a very complicated problem." Another possible refinement he mentions would be to merge the two X-ray images onto one monitor by assigning one color to high-Z objects and one to low-Z objects.

The Model Z alone is not going to stop air terrorism. Terrorists might try to smuggle the plastic guns on board a plane by hiding them on their person. In addition, the machine depends on the performance of human operators monitoring the screens. But it will undoubtedly let security specialists sleep just a little easier. **PS**

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New products

RECREATION

Along with May flowers returns the lure of the outdoors. Various gear gets dusted off, tightened up, perhaps oiled at a few critical spots. While the rest of us were bundled up for the duration, builders of boats, bikes, RVs, and more were polishing their 1986 models. This special section presents a sampling of their latest products.



New-wave motor home

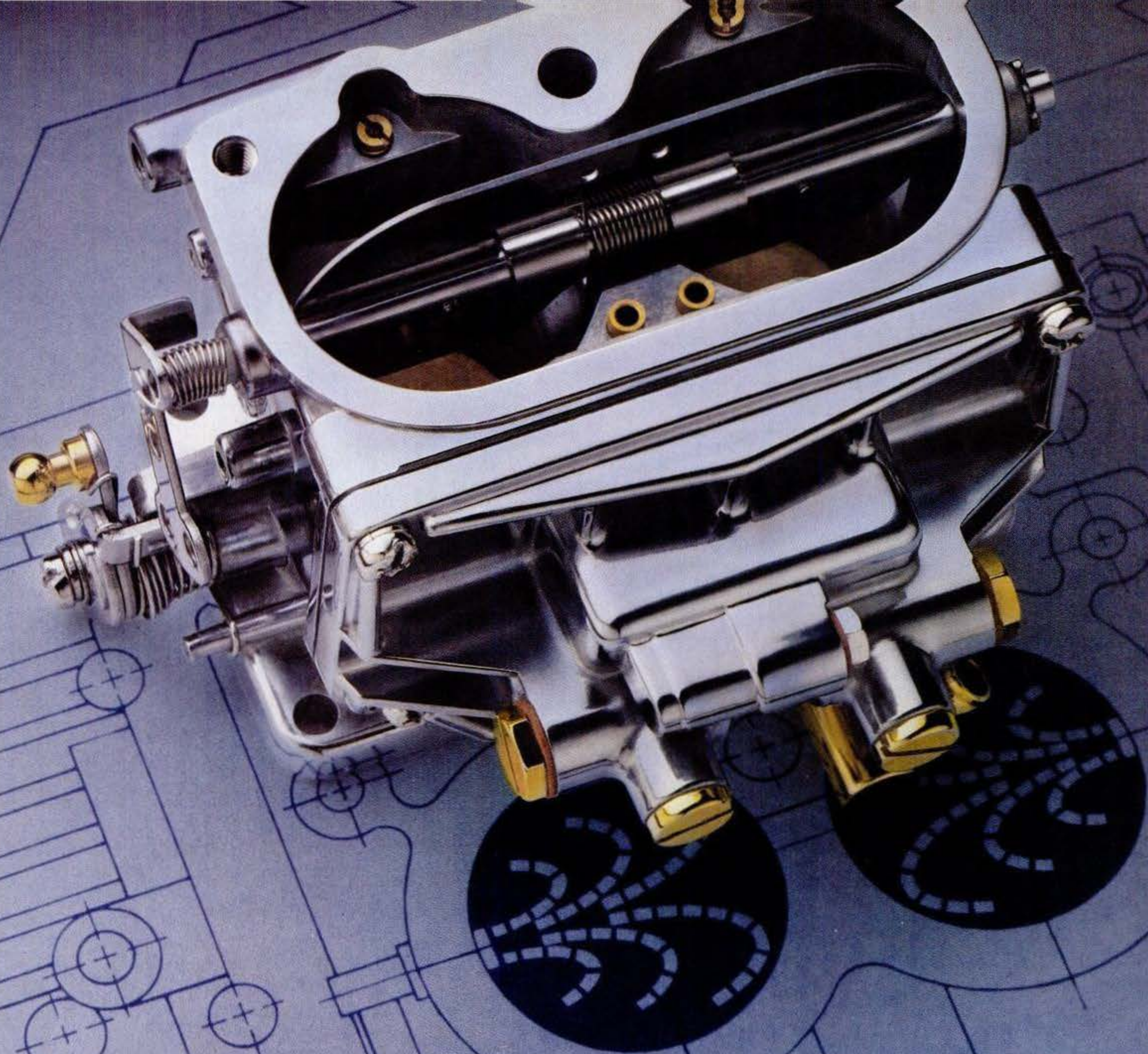
Peering into the side mirror of the prototype 21-ft. Vixen motor home, I eyed a steady stream of semitrailers cresting the hill $\frac{1}{4}$ mile away. My foot hovered above the gas pedal. "Go ahead," grinned Lyn C. Hollis, Vixen Motor Co.'s vice president of engineering, who had just pulled off the road to give me a shot at the driver's seat, "you'll be surprised." Sure, I thought, stabbing the gas pedal just as an 18-wheeler roared by. I hoped the trailer's wake would help pull us up to speed before the next truck came over that hill.

Instead, I found that the Vixen 21's 115-hp BMW turbo-diesel pulled strongly through its five-speed manual gearbox, attaining the speed limit in well under the promised 15 seconds. At 55 mph, with the engine ticking over at 2,300 rpm, a quick downshift tapped us into a healthy reserve of passing power. Then, going into an expressway off-ramp, I detected a hint of understeer as the radials grabbed for bite in the corner... wait a minute. This is a motor home. And motor homes are the butt of performance-handling jokes. But the Vixen is, well, different.

I was driving the product of five years of development by a handful of maverick auto-industry veterans who rejected the basic premise of the RV industry: building custom bodies on standard truck chassis. These engineers designed the 5,100-lb. Vixen from the ground up.

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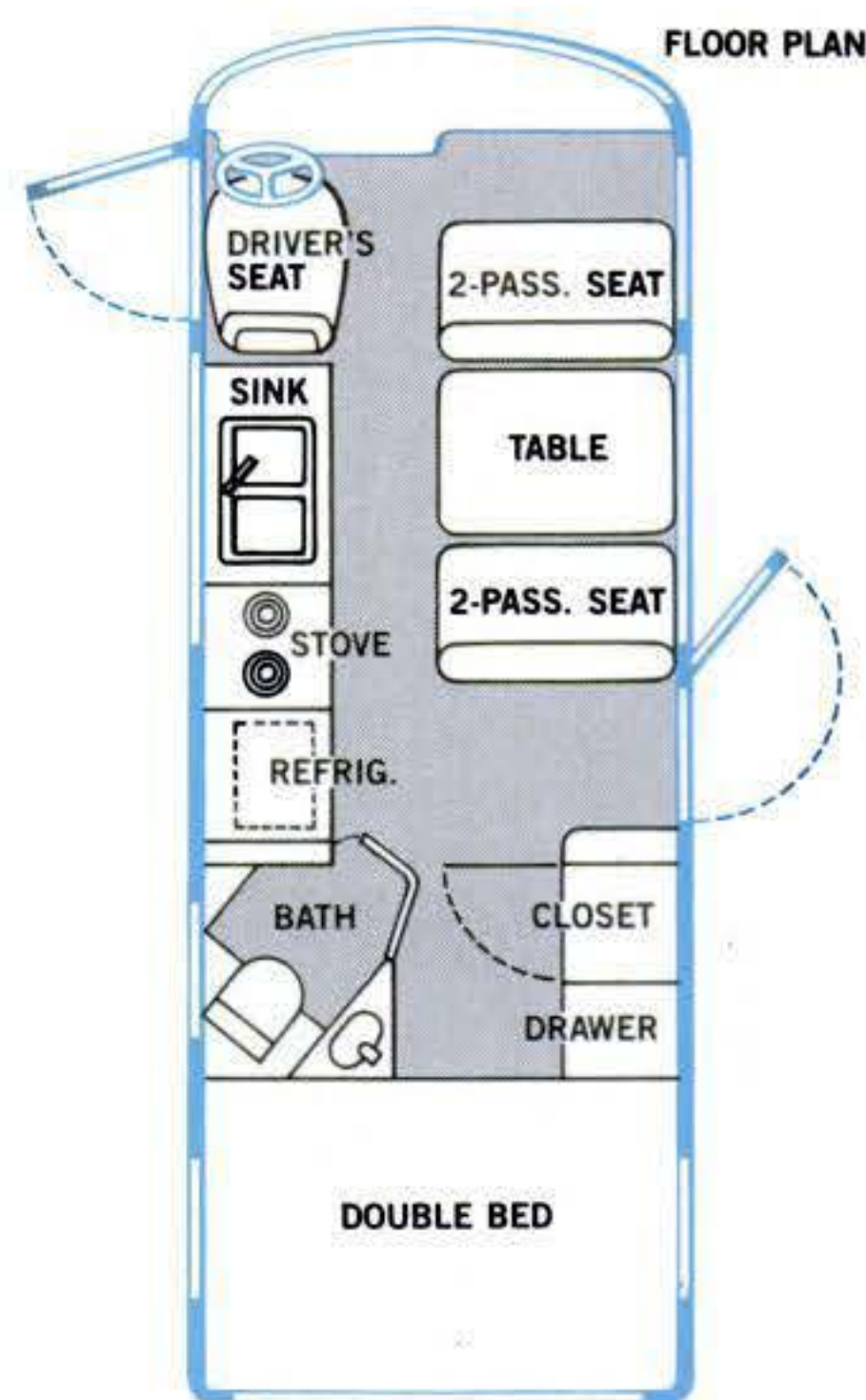
New products

RECREATION

dently to accommodate uneven terrain. The chassis itself is a heavy-steel perimeter frame that surrounds a dishlike floor pan. That's one of the biggest changes from conventional

motor-home construction, where a flat floor is usually laid on top of truck-frame rails.

The builder (Vixen Motor Co., 1 Silverdome Industrial Park, Pontiac, Mich. 48057) boasts a 0.295 coefficient of drag, lower than all but the slipperiest production cars. With a small frontal area—a result of its low (76-in.) overall height—Vixen's designers are claiming a steady-state 30 mpg from the rear-mounted 2.4-liter engine



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at 55 mph. "We designed the Vixen to drive from here to there, not to park in Florida for a few months," observes Hollis.

The Vixen has a sunken floor, but still allows only 5½ ft. of head room while underway; this lack of full standing room is bound to be controversial. When the vehicle is parked, a pop-top that rises along one side on air struts provides some measure of relief; it increases head room to 6½ ft. The Vixen 21 is \$35,000, complete with microwave oven and full double bed. —Dan McCosh



Ford-powered streamliner

ElDorado Motor Corp.'s designers took advantage of the driver's location—behind the front wheels, not over them—in Ford's new Class-A motorhome chassis when they created the wedge-nosed Starfire. The result: improved aerodynamics for better mileage and less wind noise, the company claims. The entire body (minus the hood) is fabricated in one piece using fiberglass-reinforced plastic combined with honeycomb material for a high strength-to-weight ratio, says the builder. ElDorado (Box 266, Minneapolis, Kan. 67467) offers three floor plans starting at under \$60,000.

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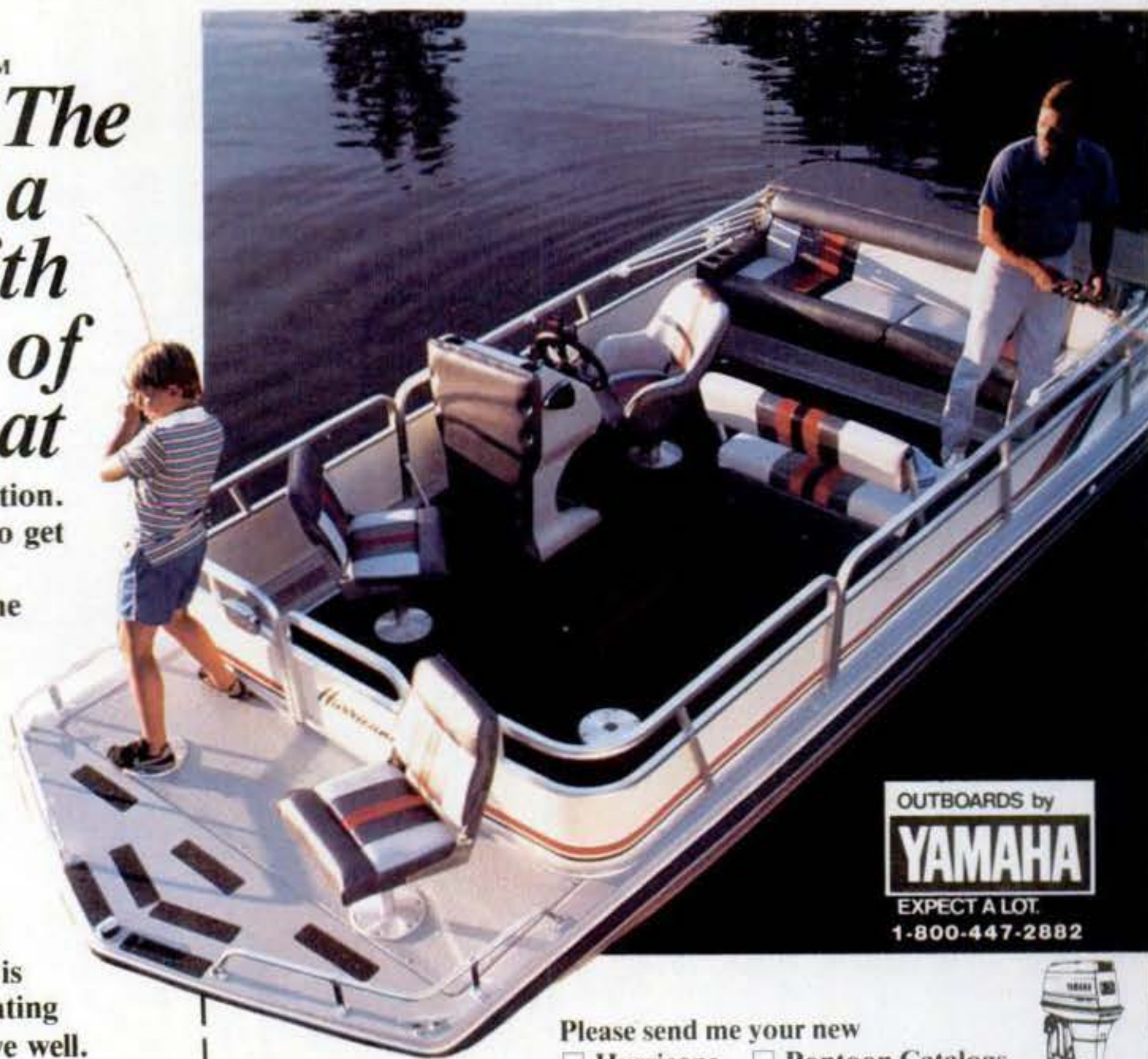
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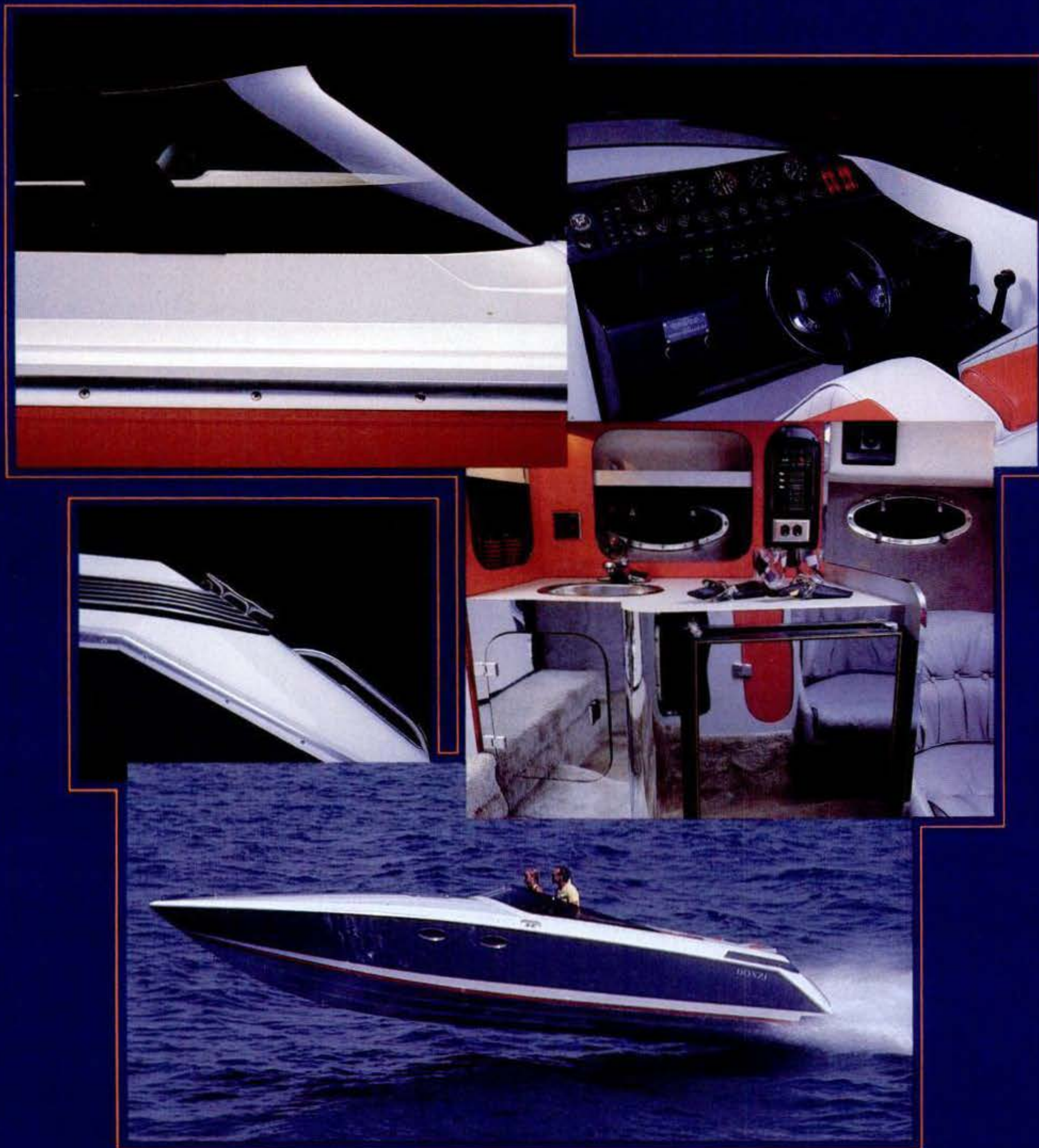
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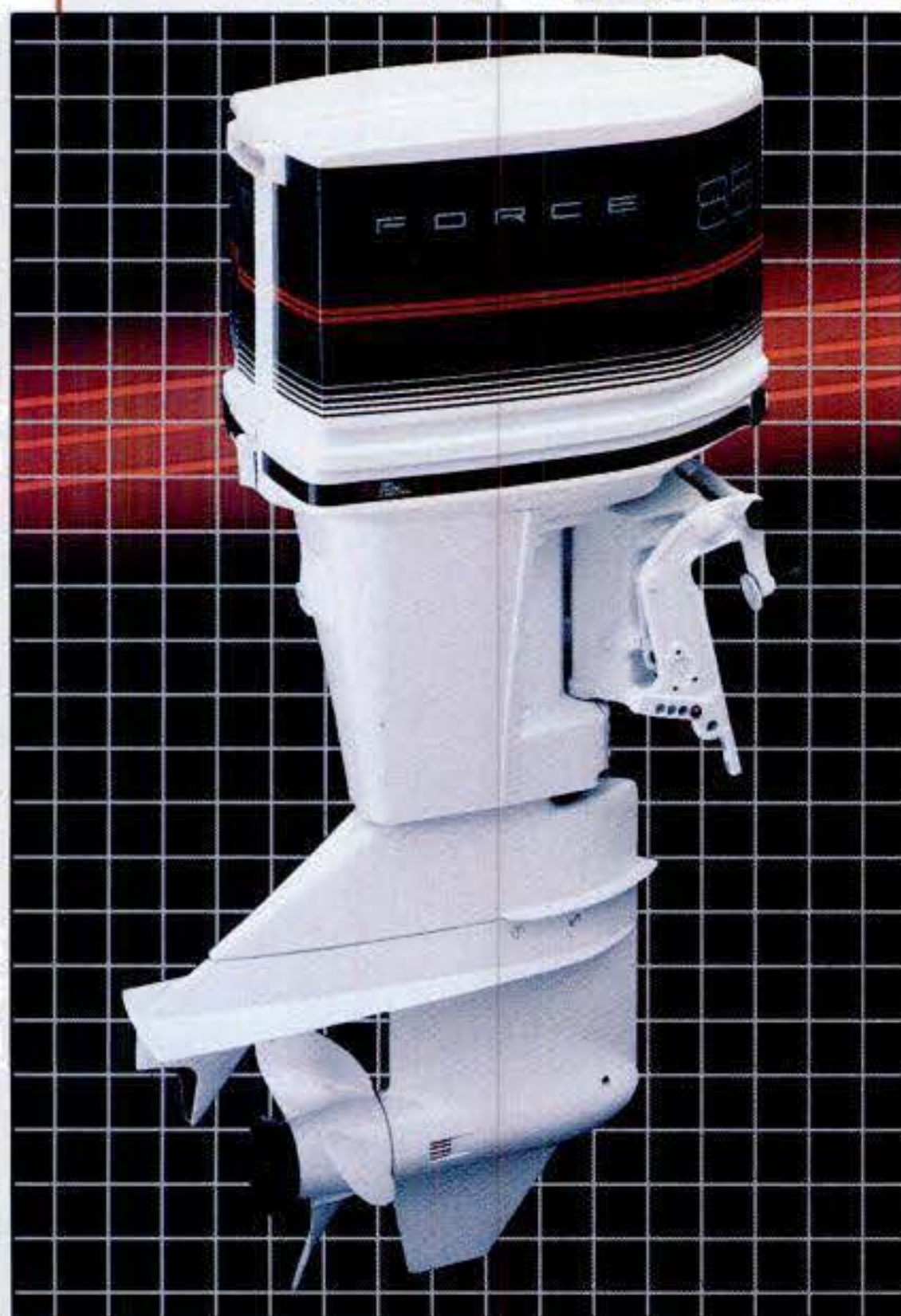
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You also don't get expensive gadgetry. Instead, Force engines rely on the proven dependability of straightforward engineering, refined to deliver spirited, economical performance, time after time.

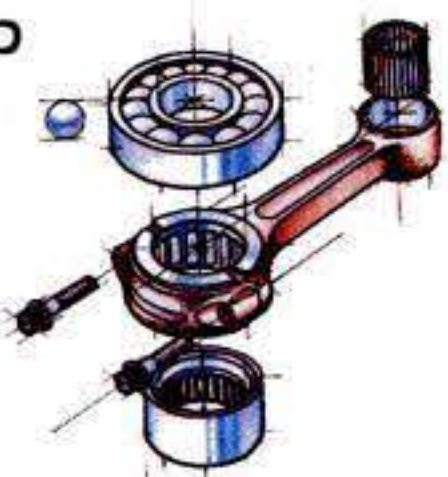
What you do get is an unbeatable value—backed by 50 years of engine building experience—no matter which model you choose. You get smooth, quiet operation, remarkable economy and exceptional power-to-weight ratios.

So if the high price of most outboard engines has kept your boating plans on the beach, you owe yourself a look at the exciting Force line-up for 1986. Size for size, every Force outboard delivers everything you'd expect from a high-priced engine. Except a high price.

See them all at your Force dealer. Find him in the yellow pages, or write for the name of the dealer nearest you.

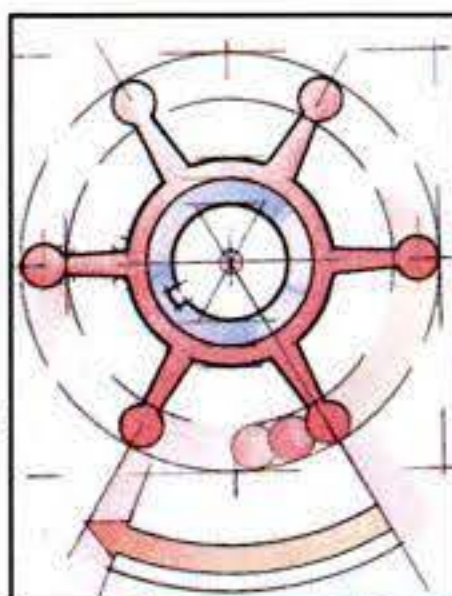
ANTI-FRICTION POWERHEAD

Every Force powerhead is engineered to virtually eliminate friction; optimum application of roller, tapered roller, ball and needle bearings resist friction and wear, assure smooth operation and longer engine life.

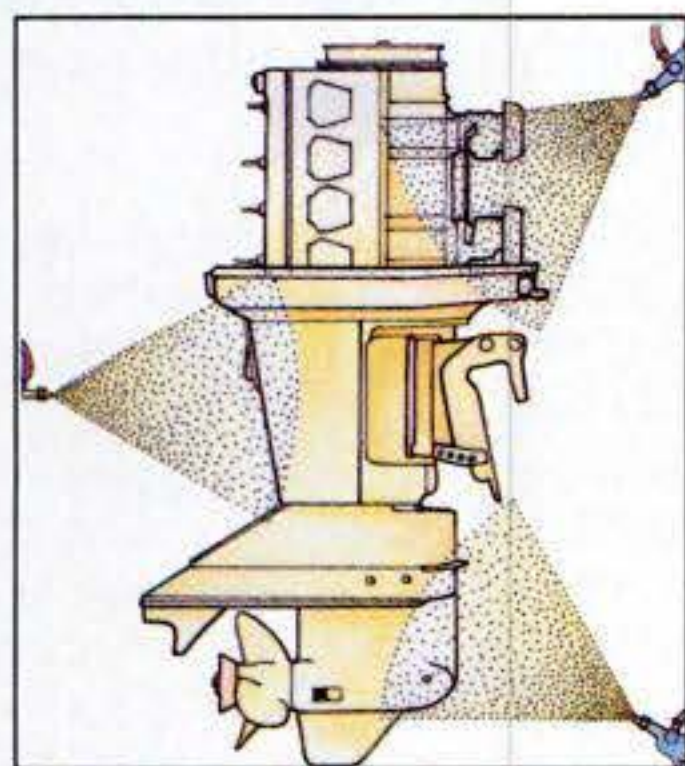
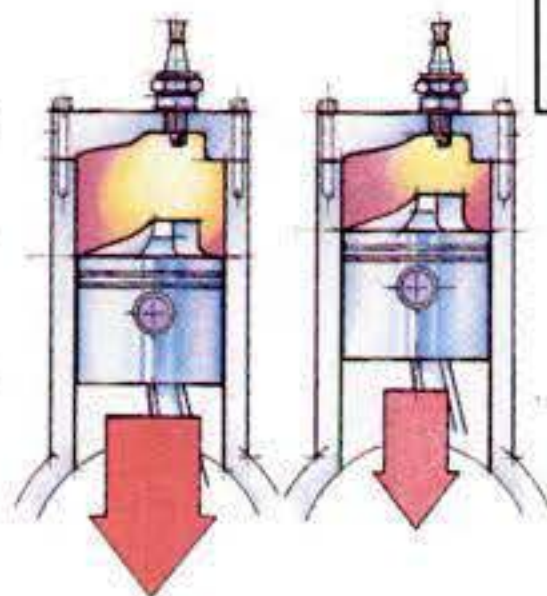


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Every Force outboard is fitted with a specially-designed water pump with quality synthetic impeller to provide reserve capacity and trouble-free operation.

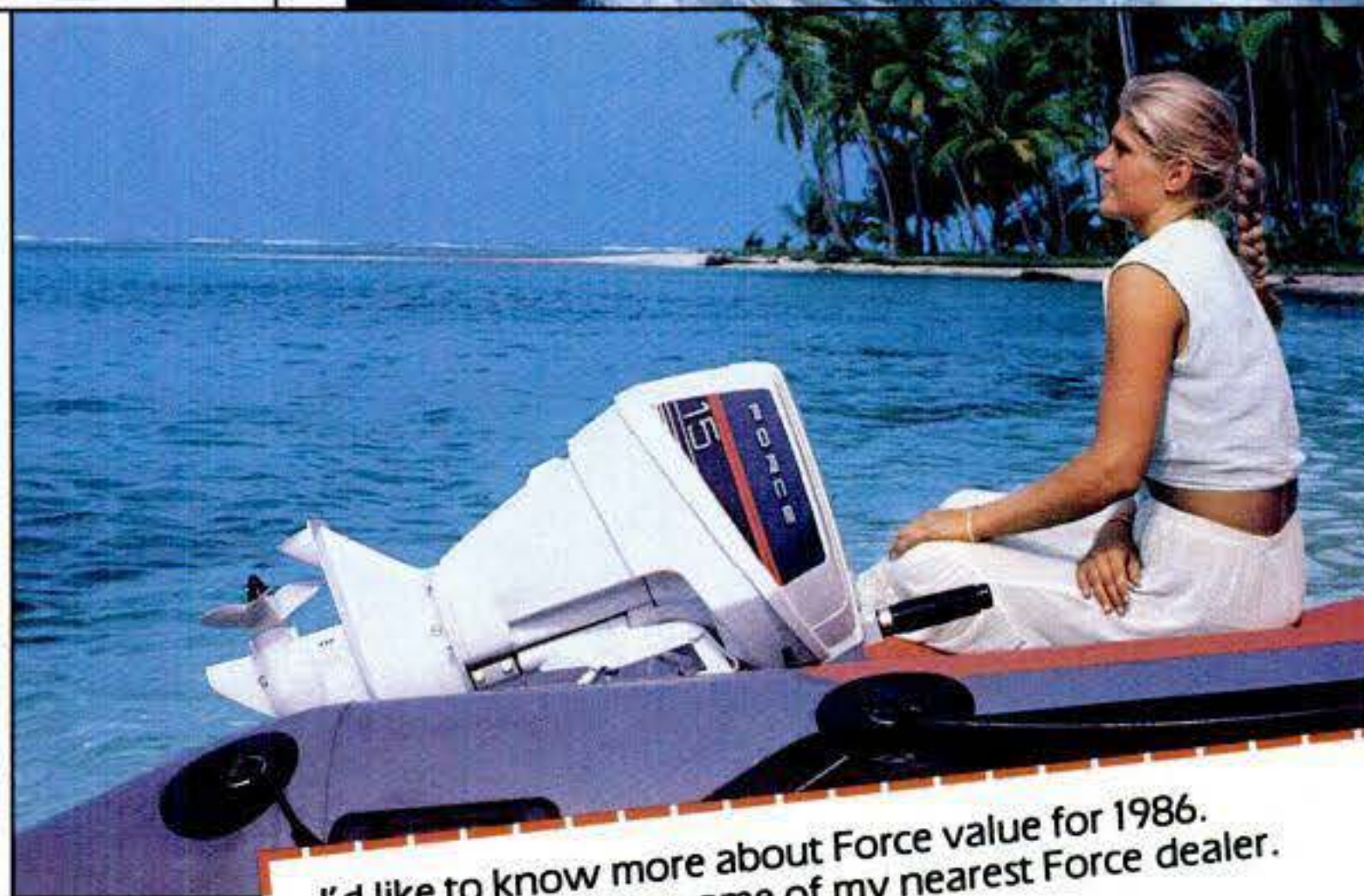


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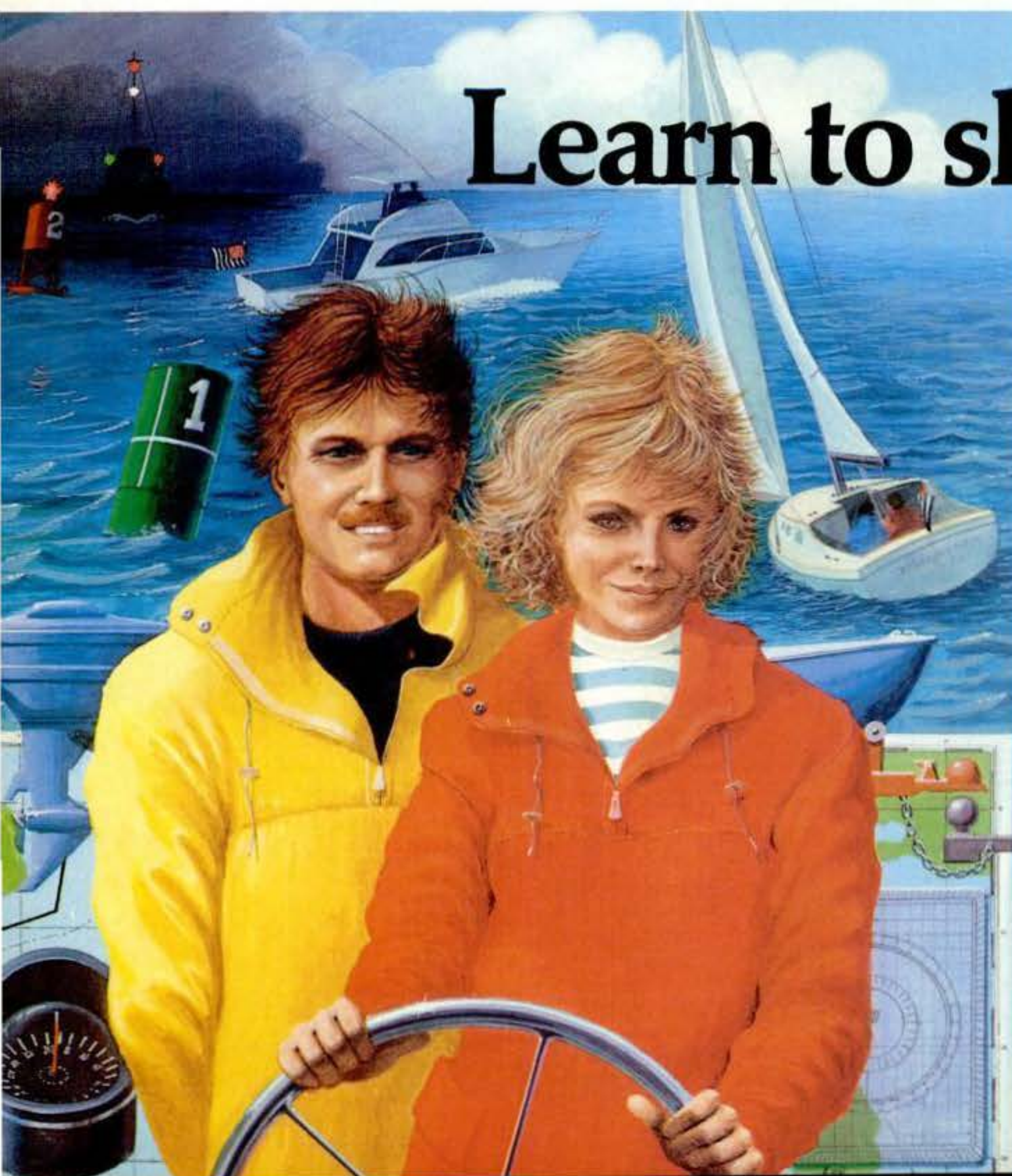
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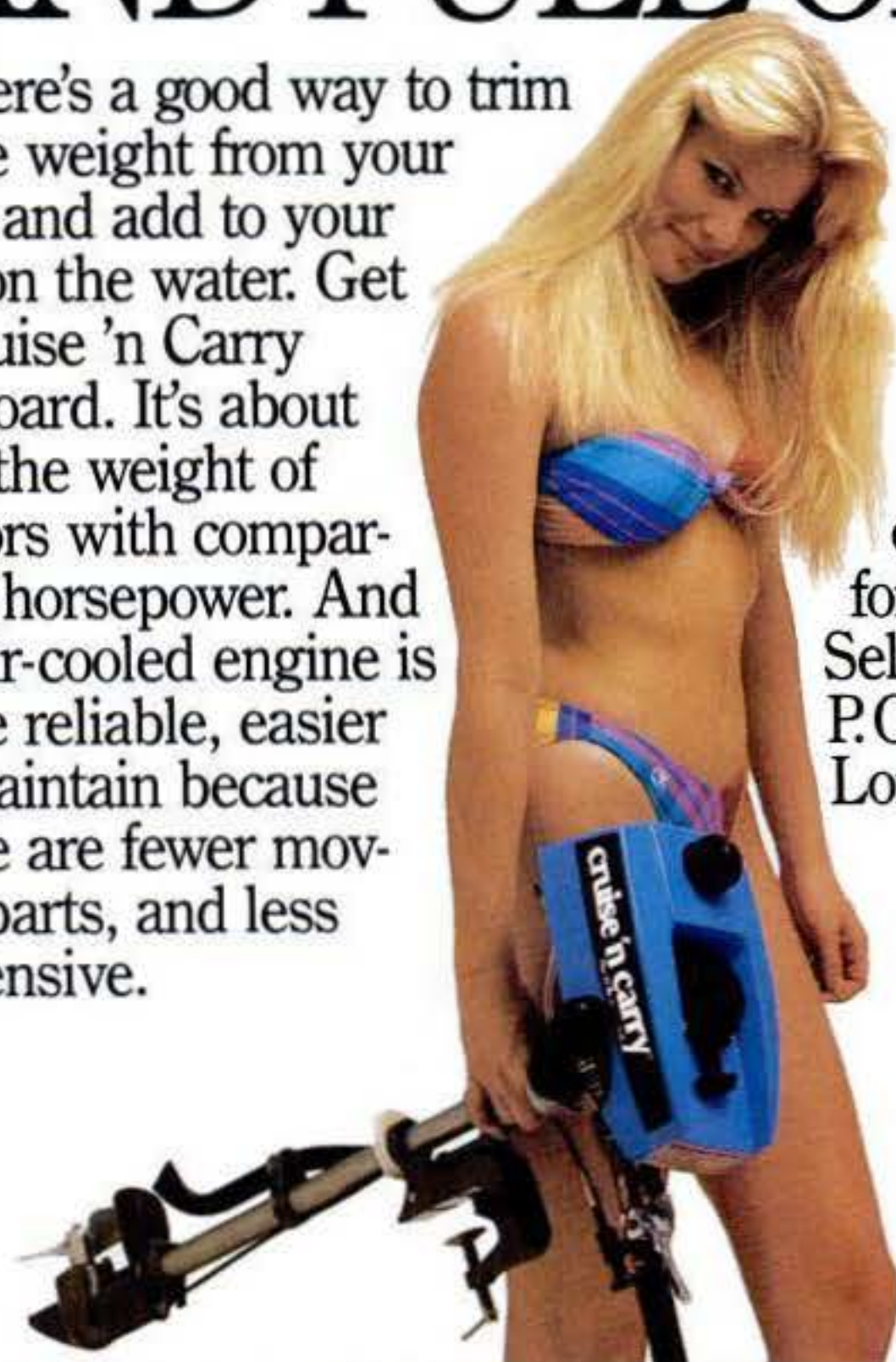
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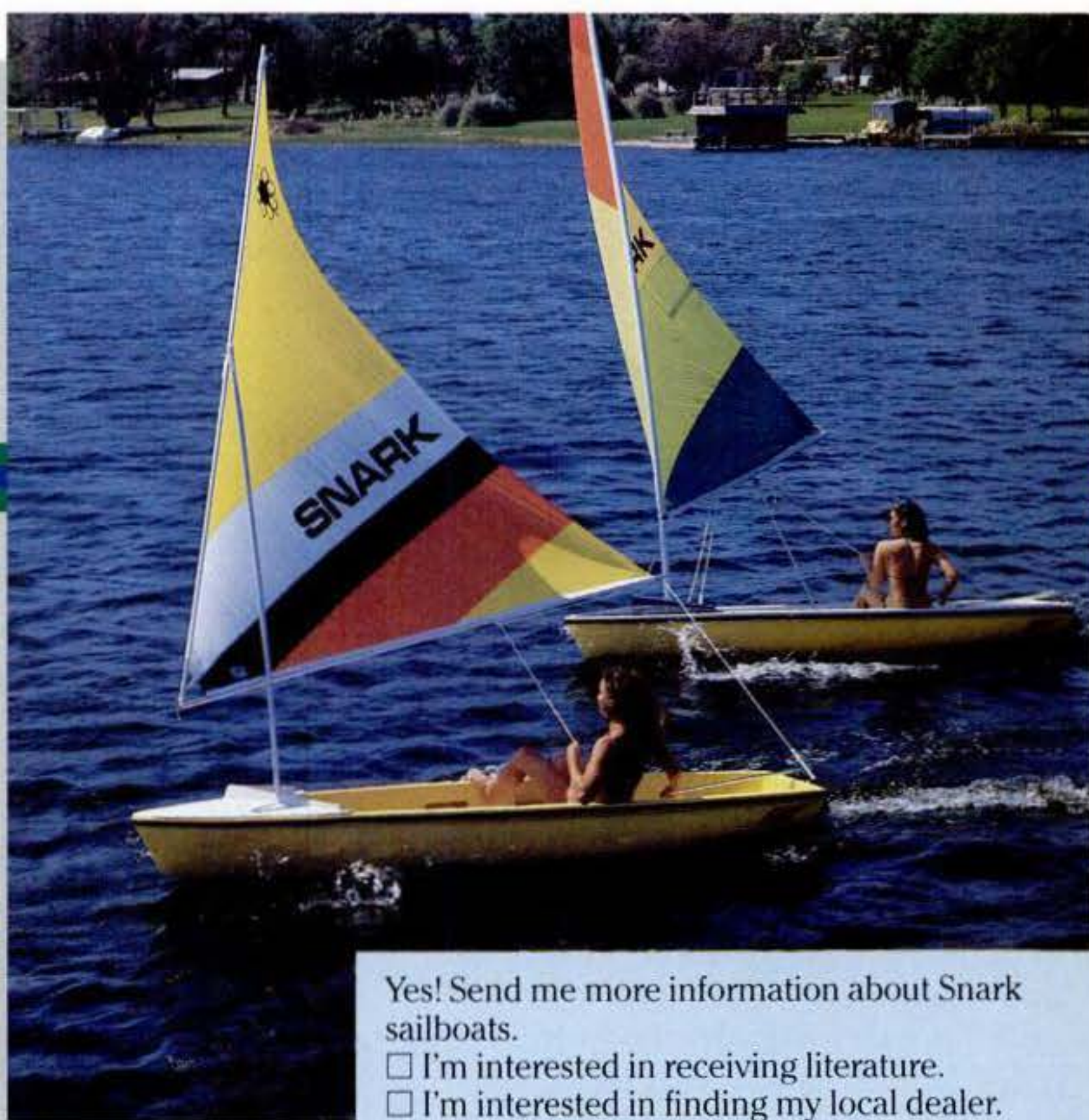
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Designed by a fisherman, the 340 includes twin rack and pinion steering, dual rear livewells, 7' rod box, and plenty of storage space. Choose

between a fold-down seating arrangement or the wrap-around design.

Hit the throttle on Yamaha's ProV, and you'll know what it means to handle 150 high-performance horses. Its high-performance gearcase and 2:1 special gear ratio deliver eye-watering acceleration and its stream-lined design knifes through the water. Hard rubber mounts deliver better high-speed stability and steering response. The extended gearcase features lowered water intakes and speedometer Pitot for high motor mounting and jack plates. And Yamaha includes its exclusive two-year limited warranty.

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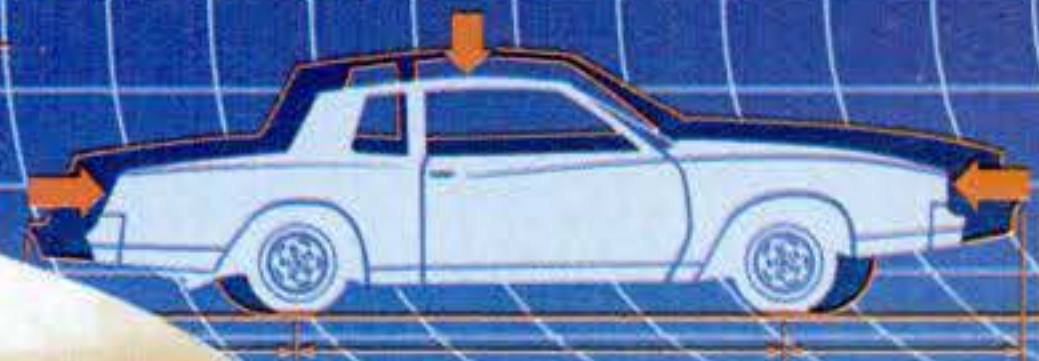
Easier steering for big outboards

Precise control with little effort at the steering wheel is the goal of two new engine features. Outboard Marine Corp. (Box 663, Milwaukee, Wis. 53201) has developed an automotive-type double-acting power-steering system it says overcomes the sideways-pulling effect of prop torque. It's standard equipment on Johnson model 275 (right) and 3.6 GT V8 engines, and on Evinrude 275 and 3.6 XP V8s.



Yamaha Outboards (Box 6555, Cypress, Calif. 90630) now offers pairs of V6 150-hp (left) and 200-hp engines with counterrotating propellers to balance engine torque and keep the boat on an even keel. One prop is driven full-time in reverse through a special lower gear case with extra bearings to handle the stresses of extended reverse running. Since 1985, OMC has supplied counterrotating propellers as an option on pairs of its V8 engines. OMC's mechanical solution is to reverse the crankshaft rotation direction of one of the engines.

How to Tow With Today's Car and save up to \$15 at U-Haul



New cars are built lighter to save gas. So when you tow, you want added protection for your car. Here are a few tips to follow:

1. THE RIGHT HITCH.

Hitches differ. The wrong one can cause body damage or tear out. U-Haul® Hitch World® provides the hitch to fit your towing needs, using top brands like Draw-Tite and Reese. Each hitch has a nationwide warranty, good as long as you own your tow vehicle.

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Towing with a downsized car causes heat build-up in the automatic transmission. That can burn the transmission's fluid and shorten its life. Hitch World selects and installs a transmission cooler, like Hayden, that extends the transmission's life by releasing the towing-caused heat.



3. A TOWING SUSPENSION.

A standard suspension is basically made to carry passengers. Frequent trailer towing can reduce the life of your springs and shocks. Hitch World installs air lifts or air shocks that give your tow vehicle added frame support, and reduce suspension and tire wear.

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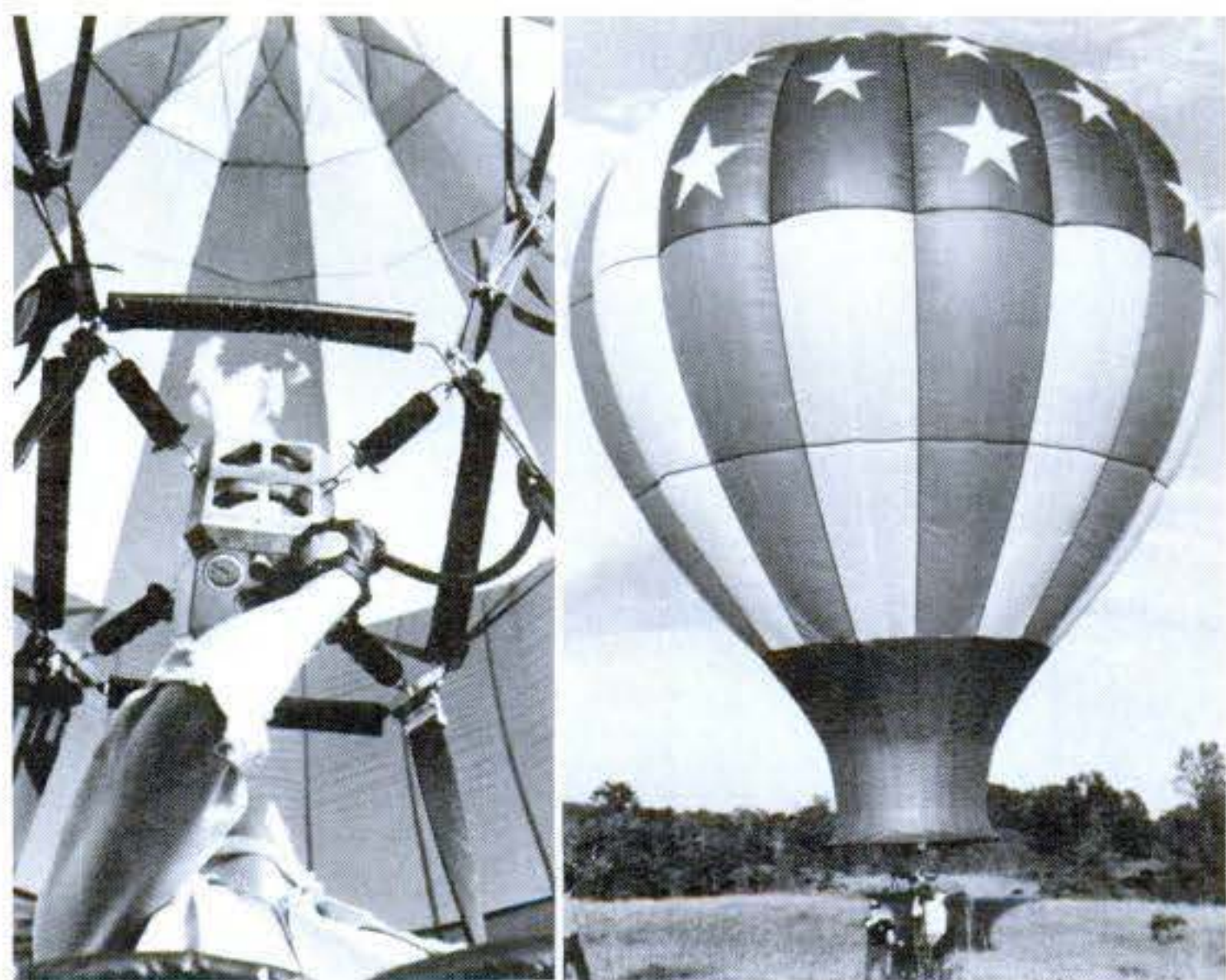
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New products

RECREATION

Water-based ultralight

Eight airtight fabric chambers stiffened with internal support baffles are built into these inflatable aircraft floats. The payoff for ultralights is better landing shock absorption with less weight than aluminum or fiberglass floats, says Full Lotus Mfg. Inc. (406-5940 No. 6 Rd., Richmond, B.C., Canada V6V 1Z1). A pair costs \$1,795, plus shipping.



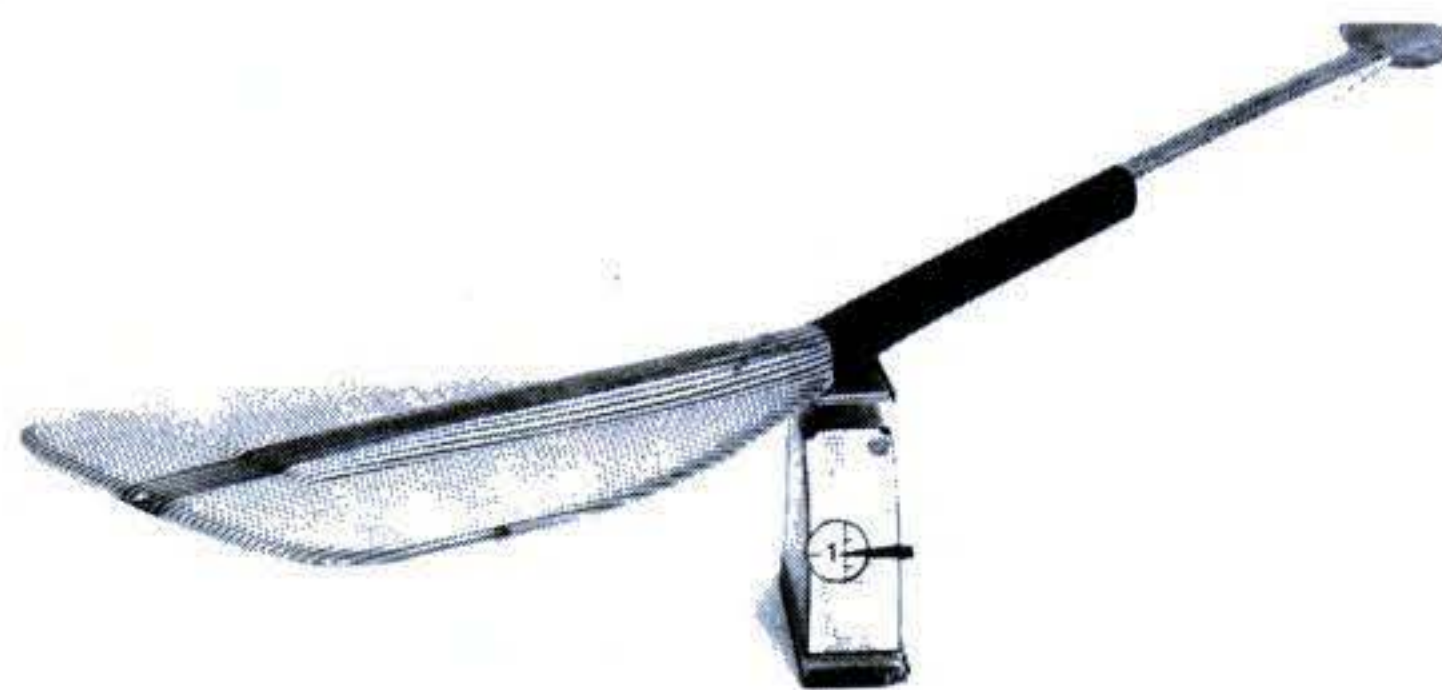
Solo ascent into the blue

No conversation, no copilot, just your own gondola from which to gaze down at the world: These are the benefits of the 152-lb. SS-103 single-occupant hot-air balloon, claims Solo System (265 Front St., Mattawan, Mich. 49071). The balloon, which uses a high-output burner with one-hand operation, can lift 500 lbs. Base price is \$6,995.



Radar on a budget

Apelco Marine Electronics (1107 N. Ward St., Tampa, Fla. 33607) says its LDR 9900 radar is the smallest and lightest full-function system available. The \$1,495 unit features an LCD screen with constant 360° display.



Featherweight canoe paddle

Aerospace-composite construction gives the \$89 Elbo canoe paddle a weight of just 1 lb. The 14° blade angle improves stroke efficiency over straight paddles, says We.no.nah Canoe, Inc. (Box 247, Winona, Minn. 55987).



Belt-drive bike

A clean, quiet-running toothed belt drives three- and five-speed British bicycles. The roller beneath the rear sprocket (inset) keeps the belt wrapped

tightly around the sprocket under hard pedaling. Flanges on the sprocket maintain lateral alignment, says Tiger Cycles (6 Elsworthy Rd., London NW3 3DJ, England).

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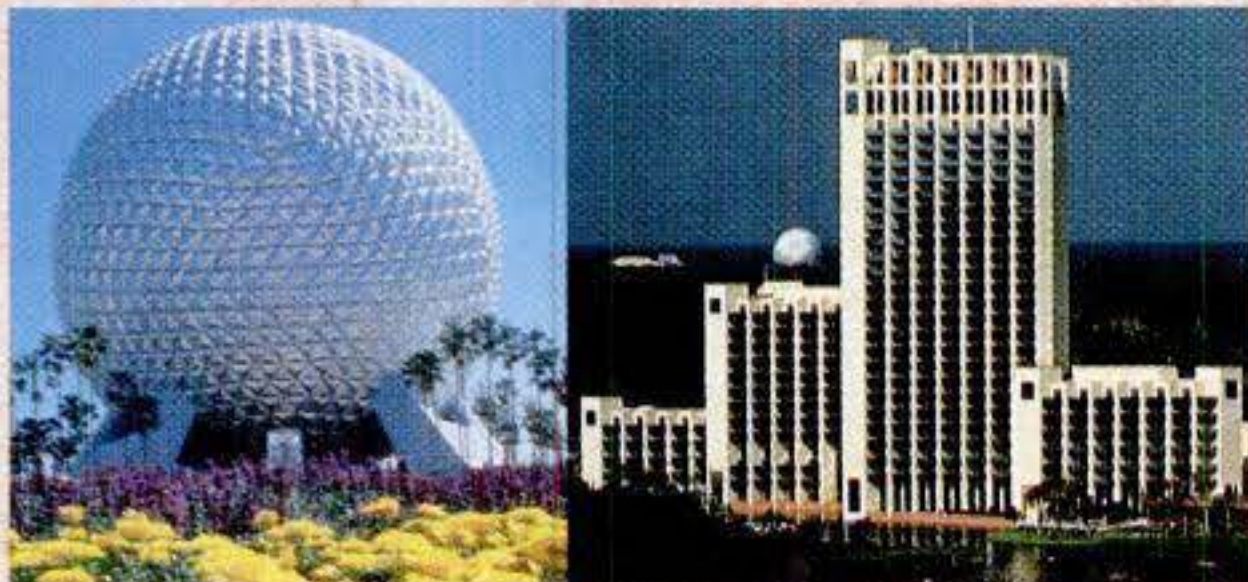
outdoors. And the opportunity to take off in a brand-new GMC truck. Even if you haven't entered the more mundane sorts of sweepstakes before, you should consider the unusually attractive opportunities presented by the GMC Truck Great Escape Sweepstakes:



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*Prizes may vary from illustrations shown due to model changes, availability, and other circumstances. See your participating GMC Truck dealer for entry forms, official rules and details. No purchase necessary. Must be 18 or older to enter. Enter at dealer by May 31, 1986. Void where prohibited.

Let's get it together . . . buckle up.



"Say, Smokey—"

A clinic on cars by Smokey Yunick,
America's most famous mechanic

Rough deceleration

Since I bought my 1984 Ford Tempo, it has made jerking motions while decelerating. The problem is more noticeable in lower gears at slower speeds, and it only occurs when the engine is warmed up. The Ford representative tells me this is characteristic of front-wheel-drive cars with standard transmissions. Do you think I am getting a straight story?

H. M. Haskins, Dexter, Maine

I don't agree that this is a normal condition. The jerking on deceleration is from incorrect fuel mixture, too much ignition timing advance, or too much EGR [exhaust-gas recirculation]. It's easy to check the EGR for malfunction by disconnecting it. Hook it back up again after the check. You can also retard the ignition timing and see if that helps. Unfortunately,

there's no good alternative to checking fuel mixture with an exhaust-gas analyzer while the car is on a wheel dynamometer.

Relentless clatter

Since I bought my 1983 Chevrolet Cavalier, it's been to the shop 20 times for the same problem: clattering. The engine clatters on the slightest hill, and with the air conditioner on, the noise gets worse. The dealer has replaced numerous ignition and fuel-injection parts on the two-liter engine. Using 92-octane unleaded gasoline helps but doesn't eliminate the problem.

Eugene A. Shannon
Farmington, Ariz.

I think a new engine-control PROM (circuit chip) No. 1226789 will help your spark-knock problem. The origi-

nal PROM allowed too much ignition advance under some engine-load and octane conditions. The new chip advances timing less at transient or low intake-manifold pressures, when knock is hardest to control.

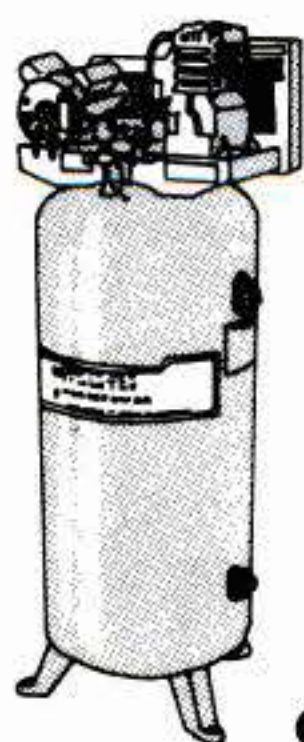
Part-throttle knock

The 3.8-liter V6 engine in my 1981 Oldsmobile Cutlass pings almost continually while cruising on a level road or up a slight grade. Strangely, I can stop the pinging by stepping on the gas pedal lightly; in fact, it pings very little under full-throttle acceleration. Ignition timing is set to factory specification. There must be a specific problem here, but the Olds dealer can't find it.

Richard L. Jennings, Lanham, Md.

The vacuum advance is probably allowing too much ignition advance at light throttle openings when manifold vacuum is high. When you open the throttle, manifold vacuum drops to nearly zero, retarding the timing. At this setting, the engine runs well. Compare your vacuum plumbing with the under-hood decal, and look for damaged or missing parts, like a vacuum-

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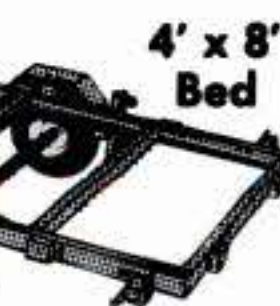
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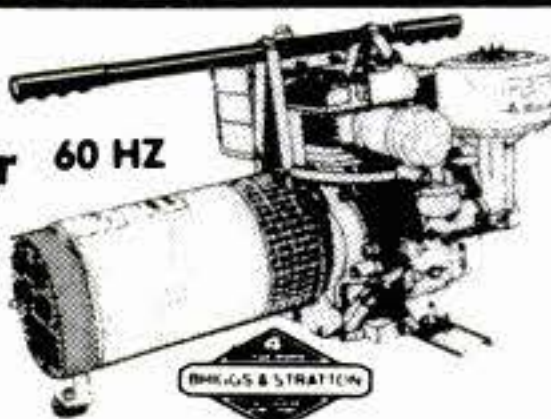


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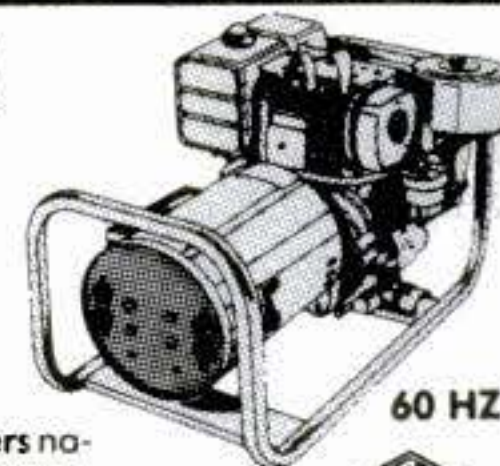
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delay switch that isn't bleeding vacuum off fast enough. A mechanic can check the vacuum and centrifugal advance curves on a testing machine.

Howling clutch

My 1984 Honda Civic station wagon developed a howling sound coming from the clutch after 5,000 miles. The sound occurs each time I start from a stop. The dealer told me not to worry about it. Now, at 15,000 miles, the howl is becoming worse.

Robert Farnsworth, Everett, Wash.

There is a fix for this problem. Start by referring to factory service bulletin No. 84-039, issued in June 1984. The noise is caused by metal-to-metal contact in the cushion-drive assembly. Though this sound doesn't signal an early mechanical failure, it's sure to drive you crazy. Stopping it calls for replacement of the clutch disc and pressure plate.

A whine behind

The rear axle on my 1981 Oldsmobile Delta 88 whines between 40 and 55 mph. When I remove my foot from the

gas pedal, the noise stops. The differential oil level is full. Mechanics say it could be worn wheel bearings or loose universal joints. Could it be a bad ring-and-pinion gear?

Ken Ramsey, Columbia Falls, Mont.

You could have a serious safety problem on your hands; check the rear axle bearings very soon. But it sounds to me more like a worn ring-and-pinion gear. There are many reasons for noisy axles, but a whine that comes and goes with speed is usually in the ring and pinion. There's no correction except for replacement.

Sticky throttle

The carburetor in my 1981 Toyota pickup gums up and sticks open when started cold; it requires cleaning every year. This winter I have been adding a can of carburetor cleaner to every tank of gasoline. I have always used no-lead gas, usually gasohol.

Robert E. Novacek, Omaha, Neb.

This problem might be caused by high alcohol-content fuel; it's not normal to have that much residue buildup with regular gasoline. If your engine has

worn piston rings or valve guides, this could also be contributing to gummy deposits in the carburetor. Blowby gases from the crankcase are routed through the carb by the PCV system.

A mind of its own

On several occasions this past winter my 1979 Plymouth Volare Slant Six with automatic transmission would roll for approximately four feet after it was placed in "Park" when parked on a hill. It would roll either forward or backward. My mechanic couldn't find anything wrong, and this hasn't happened since the warm weather hit.

Jeff Busch, Minneapolis, Minn.

It sounds like you may have had ice buildup in the linkage leading from the steering column to the transmission. If the linkage adjustment is correct and all the bushings and clips are in place, raise the hood the next time this happens, and look for ice formation in the area of the linkage.

Got a car problem? Send it to "Say, Smokey—," POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. All letters are read, and those of widest interest are answered in this column. Due to the large volume of mail, Smokey cannot reply to letters not selected for publication.

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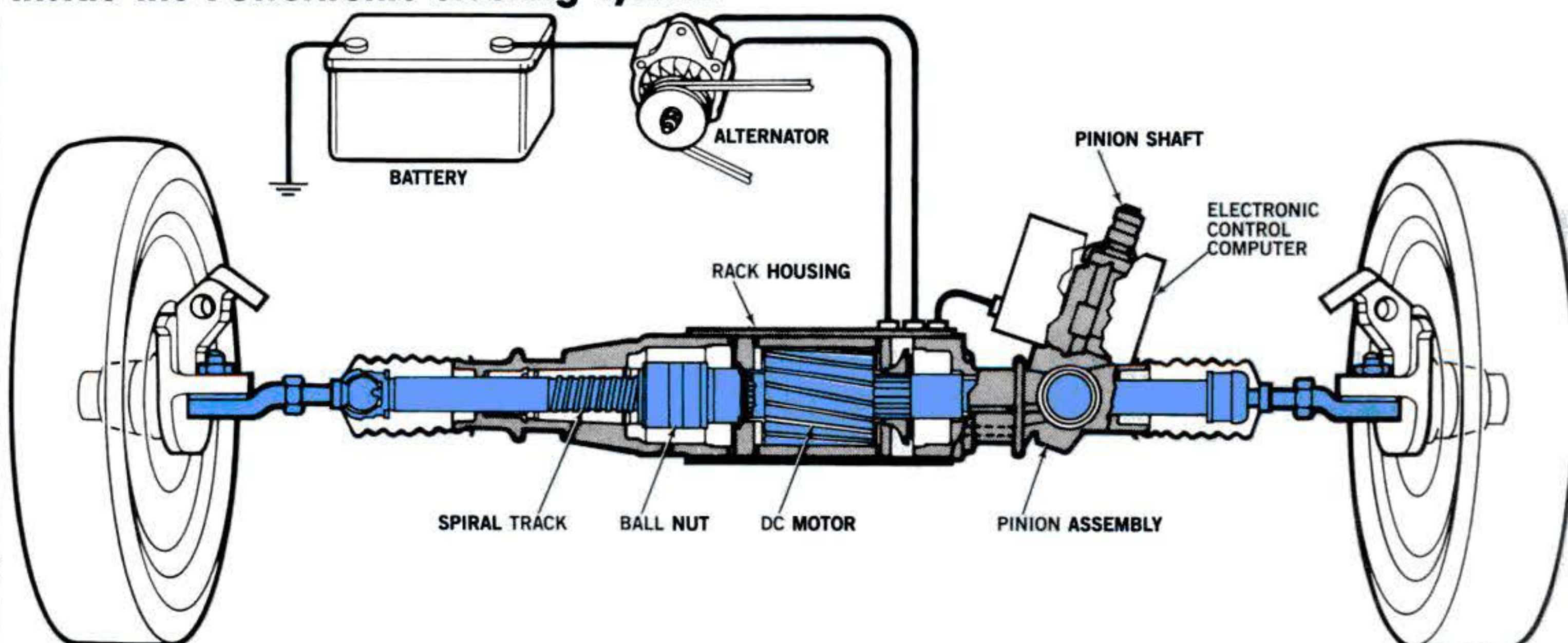
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So long, hydraulics— the electronic revolution in power steering

Power steering in which the power assist is provided by an electric motor rather than the standard hydraulic actuator is on the way. TRW's version, scheduled for production in 1988, promises better performance, less weight, improved reliability, and the ability to program steering assist to suit the driver. Other companies will follow suit quickly.

Inside the Powertronic steering system



The TRW Powertronic system uses sensors on the pinion shaft to provide a computer with information on the steering wheel's movement. Assist is then supplied by a DC motor in the rack housing. The rack passes through the hollow armature of the motor; the armature's rotation moves the rack back and forth via a ball nut, a ball-bearing-filled gear that rides in a spiral track on the rack. Speed and direc-

tion of the motor are controlled by semiconductors capable of switching up to 75 amps. The rest of the system is similar to the hydraulic rack-and-pinion steering TRW also makes. The pinion gear rides in teeth on the sliding rack, allowing the driver to steer the car if the electrical system fails. Because it doesn't rely on a belt-driven pump, Powertronic will provide assist even with a stalled engine.

By JACK KEEBLER

When it's a race between electrons and hydraulic fluid, the electrons always win," says John Colletti, engineering director of TRW's steering and suspension division.

I'm convinced. After test driving a Chrysler New Yorker with conventional hydraulically assisted steering, then switching to a car with one of TRW's new electronically controlled

power-steering units, I concluded that electrons are not only faster, they're also smooth and precise. The electronic system had excellent feel, with none of the hydraulic lag sometimes encountered when you turn a power-assisted steering wheel quickly.

Electronic power steering promises many advantages, TRW engineers say. It is lighter, more compact, and more reliable than hydraulic steering. Its control computer can be programmed to provide varying levels of steering

assist and can interact with other computers in the car. It may help make four-wheel steering practical and may lead to future developments in suspension systems.

Although TRW's new Powertronic system uses some of the latest electronic and aerospace technology, it is far from an engineer's pipe dream. TRW plans to produce the system in volume by 1988, and General Motors' Saginaw Division appears to be close

Continued



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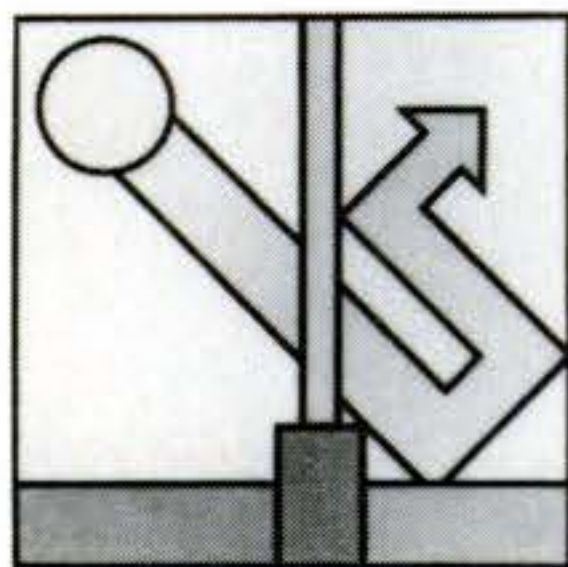
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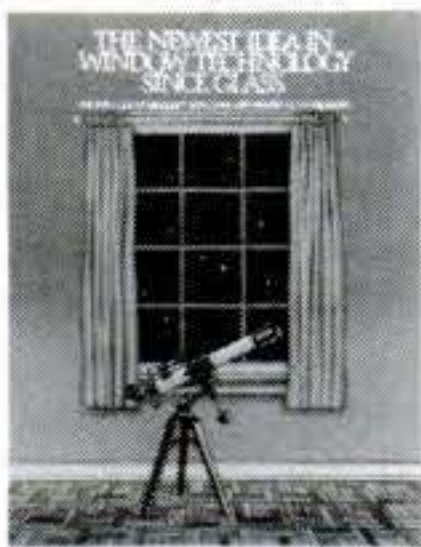
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Power steering *Continued*

behind with plans for its own electronic steering system.

Programmed steering

Conventional power steering uses a hydraulic cylinder to assist the mechanical steering gear. Power is provided by an engine-driven pump, and the hydraulic pressure is switched by a valve on the steering input shaft.

Electronic power steering replaces the hydraulic cylinder with an electric motor, which gets its power from the car's battery and alternator. When you turn the steering wheel, a sensor detects the motion and gives the electrical assist motor enough power to turn the car's front wheels the proper amount. Instead of a hydraulic control valve, the TRW system uses electronic switches.

One challenge in designing this all-new system was to find a way to control the electric motor that provides the assist. Not only did the motor have to change directions instantly, it also had to deliver exactly the right amount of torque at all times. In a sharp turn, this meant the motor could demand a current flow of up to 75 amps, beyond the capacity of microcircuits. That problem was solved with new silicon chips that can rapidly switch high-amperage current ["The Control Revolution," PS, Nov. '85].

Another problem was finding a way to mount the motor on the steering rack—the steel rod that mates with the pinion gear on the lower end of the steering column and actually transmits the steering motion to the front wheels. One early design had the motor on the steering unit's input shaft. Another put it below the steering unit and drove the rack via its own set of gears. But both lacked what engineers call "returnability": If power to the motor failed during a turn, the wheels were difficult to return to the straight-ahead position.

Then in 1981, Gilbert Drutchas, a TRW engineer, got a patent for a power-steering unit that uses an electric motor with a hollow armature, which allows the rack to pass right through its center. This became the heart of the Powertronic system. The small DC motor, built with the help of a TRW defense division, fits into the center of the housing and moves the rack by spinning a ball-bearing-filled gear that travels in a spiral track in the rack (see drawing). The pinion gear and toothed rack allow the car to be steered if the power assist fails, and tie rods and ball joints transfer steering to the front wheels.

Because of its control computer, electronic steering can be programmed in a number of ways. The car maker can

provide the lightly assisted steering desired by performance drivers or full assist demanded by luxury-car owners.

With a different program, steering assist can be made proportional to vehicle speed. The driver can have maximum power when parking; on the highway, where less assist is necessary, the computer can trim back power to the motor for improved feel.

TRW has even proposed a system that allows the driver to change steering feel with a switch on the instrument panel, choosing a full-power, manual, or speed-proportional setting. Yet another program would allow the steering to interact with braking, suspension, transmission, and other systems. This ability to make the steering interact with other systems controlled by computers intrigues car makers like General Motors.

"The type of suspension you have determines in many cases what kind of responses you want from your steering," explains Raymond J. Schultz, director of product engineering at GM's Saginaw Division. "Electric power steering will allow us to tailor steering-gear response to variable-rate and variable-damping suspension systems. It will provide the opportunity to marry the ride and handling of the car to the steering."

Another advantage: Electronic steering doesn't leak. A typical hydraulic system holds some four quarts of fluid, which can leak from damaged O-rings, split hoses, or cracks in metal parts. Such leaks now account for two out of three steering-system warranty complaints.

Because the hydraulic pump, hydraulic hoses, and drive belt can be eliminated, there are fewer parts. TRW says the system weighs 25 percent less than hydraulic steering, and its compact design means more room under the hood. And because the steering unit is not driven directly off the engine, there's a 1/2-mile-per-gallon fuel-economy bonus.

Finally, unlike hydraulic power steering, an electronic system continues to provide assist if the engine stalls because the power source is the battery, not an engine-driven pump.

Production plans

Unlike many promising inventions that never become a reality, TRW's Powertronic is being rushed into production. A plant in Rogersville, Tenn., has been selected, and power-steering units should be rolling off the line by early 1988.

"We expect to produce 30,000 units for 1988 cars," says William R. Price, vice president and general manager

Continued

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Power steering *Continued*

of TRW's Steering and Suspension Division. "By 1992, we forecast that more than three million electronically controlled steering systems will be manufactured for the North American market."

Industry reports indicate that other makers, including GM and Bendix, are also developing electronic power steering. And a GM engineer confirmed that the Saginaw Division has been working on an electronic system since 1980.

"We have several vehicles running with electric power-steering systems," says GM's Schultz. "There is currently a proposal to move into a low-volume production phase for 1988 and '89."

The future

As electronic power-steering units become available, they will solve many of the linkage and hydraulic problems associated with four-wheel steering systems [PS, Feb.]. TRW engineers say that Powertronic could make four-wheel steering practical.

Another promising application is for mid-engine cars. The current Fiero, for instance, must use manual steering because of problems in piping hydraulic power from the engine to the steering rack.

The technology developed for Powertronic could lead to other advanced products. Late at night, after TRW's presentation and dinner, several journalists and Michael J. Ryan, TRW's program director for electronically controlled steering, gathered near the steering display to discuss some last-minute questions and take a final look at the chromed Powertronic unit.

Staring at the steering rack, I suddenly noticed how much it resembled a MacPherson strut. I picked it up and stood it on end. I realized I was looking at something that might be part of what car makers call active suspension systems. These use electric motors or hydraulic cylinders instead of springs and shocks to support the vehicle and provide damping control.

Ryan looked around nervously to see whether anybody else was watching when I asked if the technology that made the steering work could also be applied to the suspension. "It could be and it has been," he replied. Then he became tight-lipped and declined to discuss active suspension any further.

An active suspension might finally allow auto makers to achieve one of their wildest dreams—a car with both a boulevard ride and high-performance handling. Just as new semiconductors helped make electronically controlled steering possible, so development work in electronic steering may yield still further advances.

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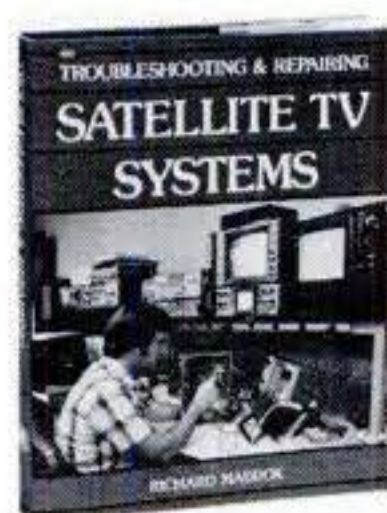


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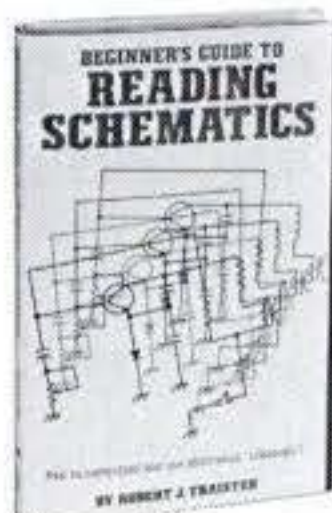
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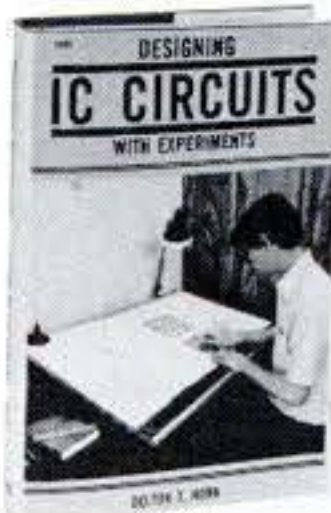
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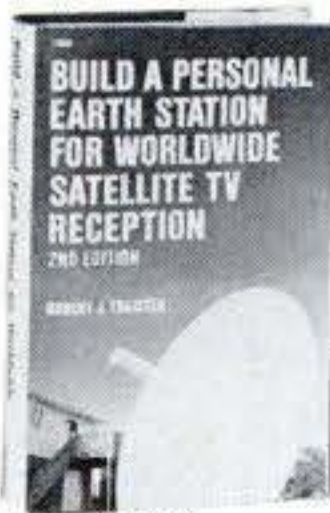
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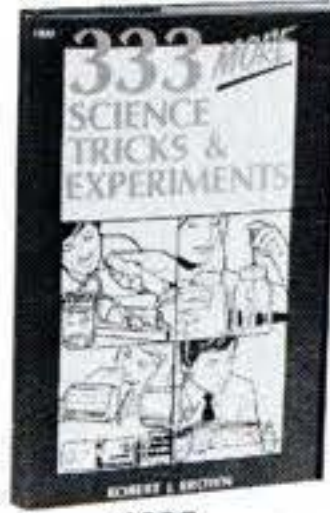
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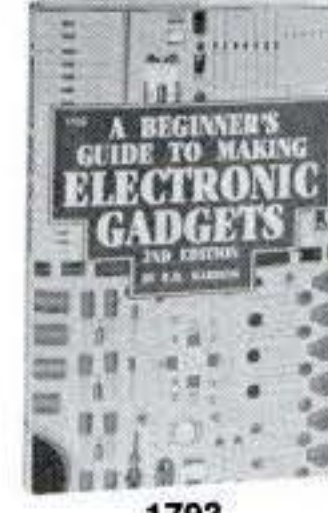
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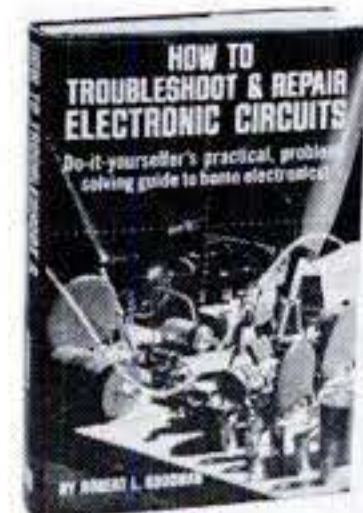
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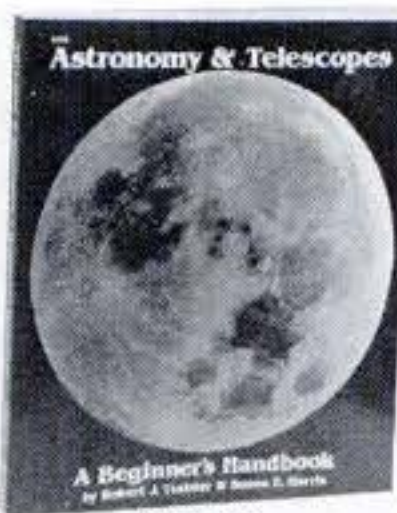
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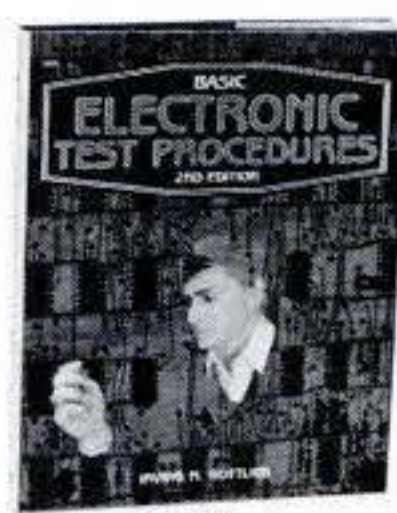
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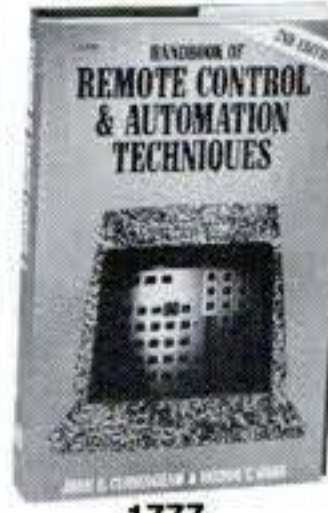
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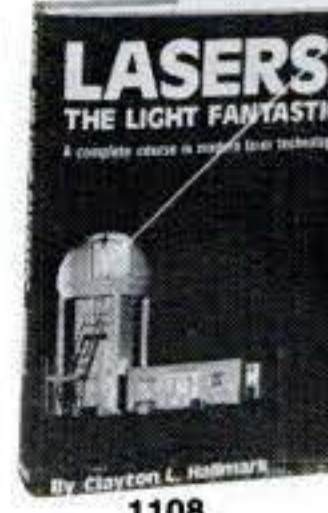
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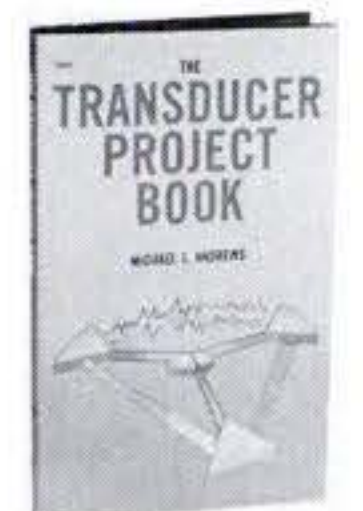
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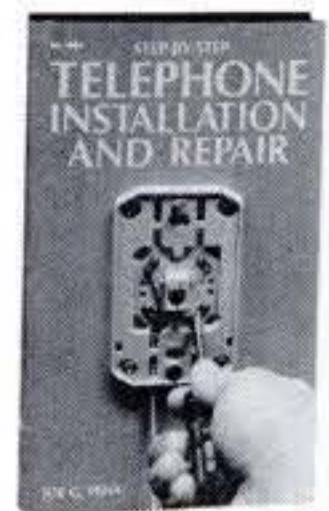
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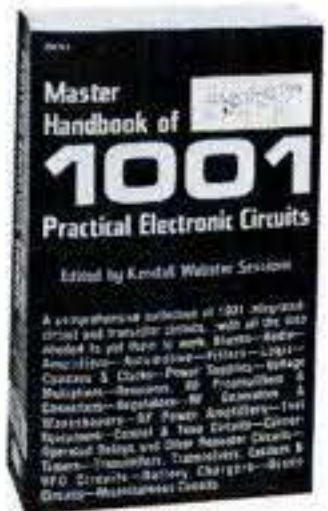
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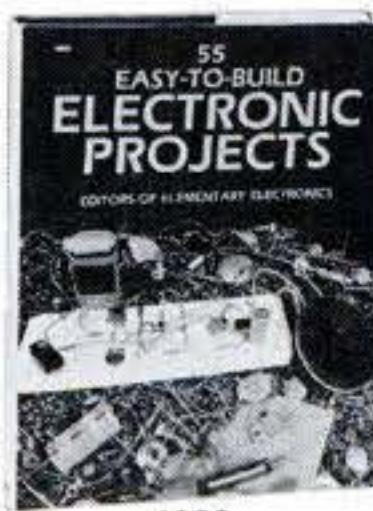
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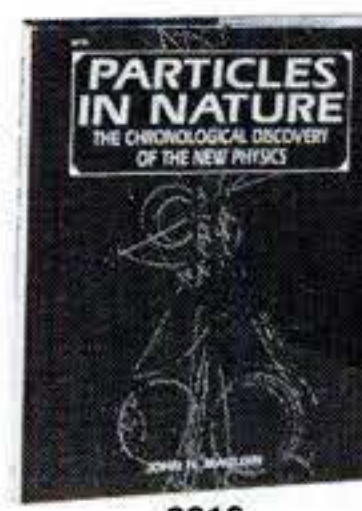
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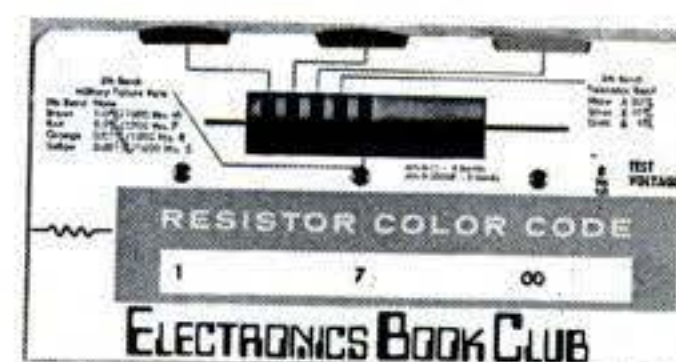
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What's New

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Plaque fighter

Rack-driven gears rotate tapered bristles both ways on the Interplak plaque-removal instrument. The 4,200-rpm motion removes disease-causing bacteria twice as effectively as manual brushing, says Dental Research Corp. (1726 Montreal Circle #14, Tucker, Ga. 30084). \$99.

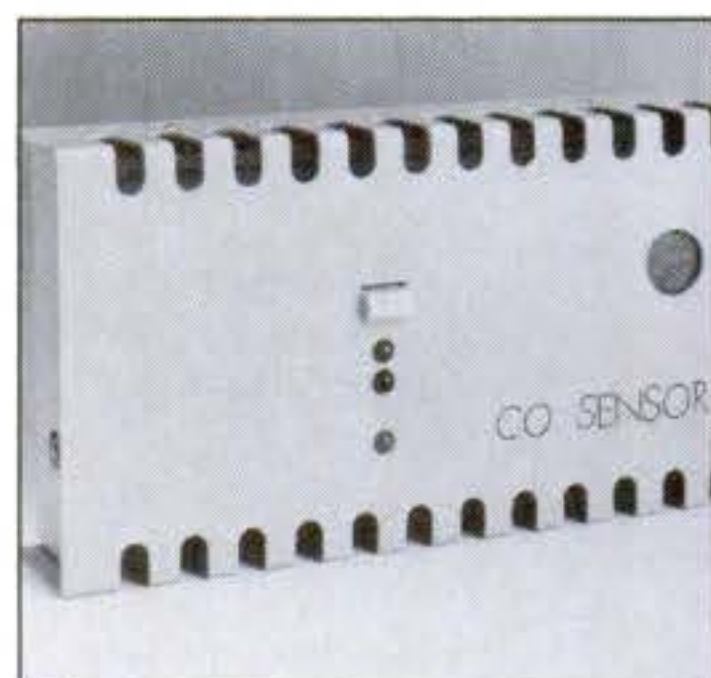
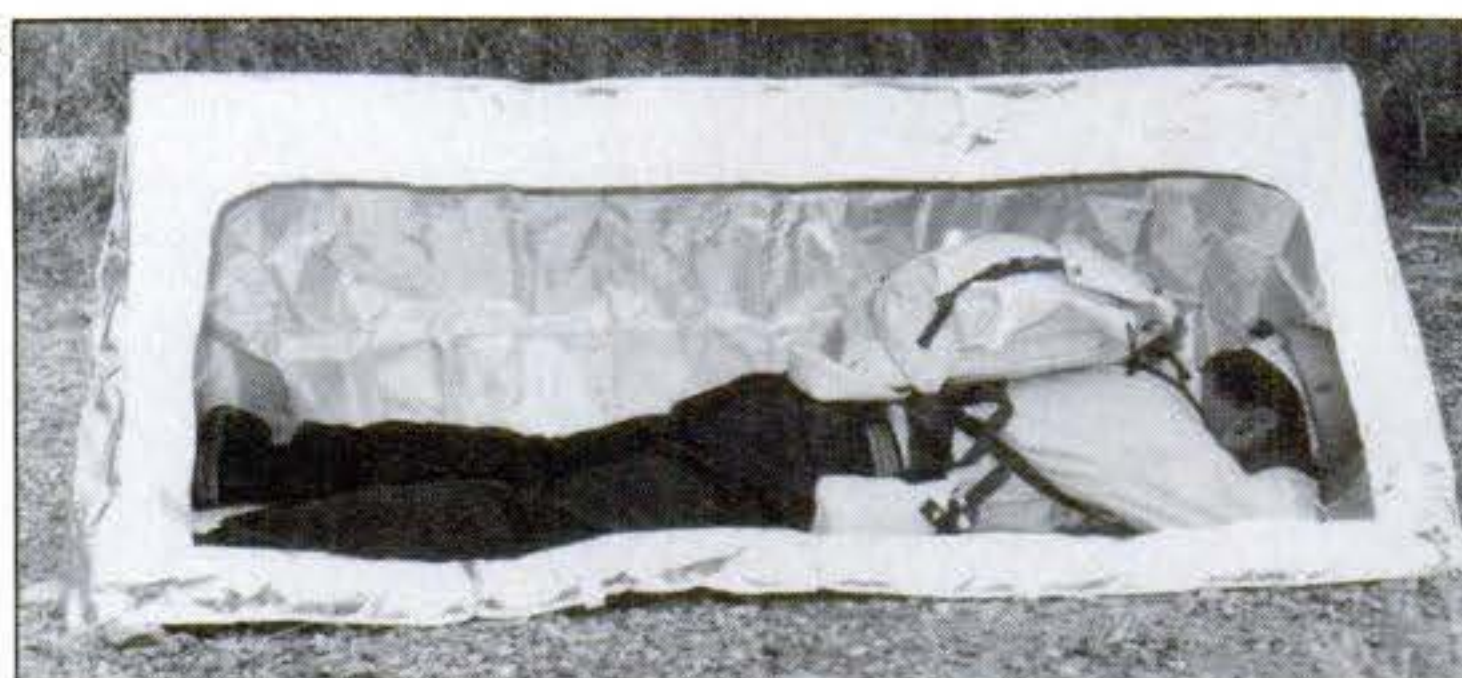
◇ Tight-turn truck

Retractable wheels on Volvo's BM 5350 trucks jack up the rear trailer for tight turns in close quarters such as tunnels. A center-pivot steering system then swings the trailer 90°. The driver lowers the wheels and drives away. Volvo BM AB, 631 Eskilstuna, Sweden.



Fire tent

When a burning forest threatens firefighters, they can deploy special shelters (cutaway) made with fiberglass cloth and aluminum foil. The 3-lb. belt-worn shelters, made for the U.S. Department of Agriculture's Forest Service, deploy quickly when a tab is pulled.



CO detector

You can detect odorless, deadly carbon monoxide gas in your house with CO Sensor, says the maker. The unit samples air every 2½ min., triggering an alarm when the gas level reaches 50 ppm. CO Sensor Intl. (160 Gibson Dr., Markham, Ont. L3R 3K1, Canada). \$170.

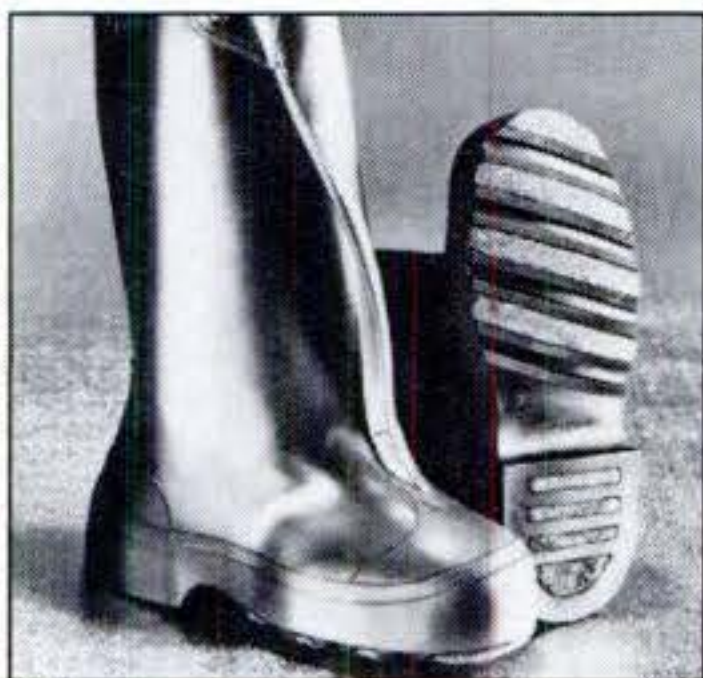
◇ Explorer cars

Battery-powered Explorer cars with tiller steering and twist-grip throttles offer cross-country travel for disabled persons, says the maker. Top speed of the Countryman (left) is 14 mph. Chair-up Ltd., Bournemouth Hurn Airport, Christchurch, Dorset BH23 6ED, England.



Advanced fighter

Long-range supersonic cruising is one goal for 1990s advanced tactical fighters to replace the F-15. New composites and metals could save 20% in weight, enabling fighters to take off and land on runways less than 1,500 ft. long. This concept is from Lockheed (Burbank, Calif.).



Self-cleaning boots

Reduce your chances of slipping on ice, mud, or other slick surfaces with its self-cleaning soles, says Jordan David Safety Products (Box 400, Warrington, Pa. 18976). Angled treads produce a shear force that clears debris from soles. A catalog details various safety footwear.



Bumperless car

A design study for Peugeot's Griffé 4 coupe eliminates ordinary bumpers, using soft impact zones in the body instead. Pininfarina, the designer, put a semitransparent roof on thin pillars to create a bubble-dome illusion. No marketing plans have been announced.

Video phone

Ordinary telephone lines carry clear pictures from one Photophone to others in 8 sec., says Image Data Corp. (7986 Mainland Dr., San Antonio, Texas 78250). The \$8,550 phone can be used to send diagrams within engineering offices or reduce travel for manufacturers.



Stylized wagon

A wagon version of Lancia's Thema sedan ["What's New," Sept. '85] adds more space and a fifth door to the top-line car. Italy's Pininfarina will install a roof, tailgate, and other parts to body shells assembled on Lancia's robotized production lines. The car is not sold here.

What's New in Tools

BY V. ELAINE GILMORE

Flip-top ladder

This 3-ft. stepladder becomes a six-footer when you flip its top section and lock its double-latch lock. The \$119 aluminum Stepmax (Disstim Corp., 217 S. Hurffville Rd., Deptford, N.J. 08096) folds into a 22½-by-8¼-by-39¼-in. package that fits in most car trunks.



Wieldy mower

With its 32-in. mower deck, the Gravelly 1132 tractor has the maneuverability you need for smaller lawns, says the maker. It's powered by an 11-hp Briggs & Stratton engine and delivers speeds from 0.8 to 4.5 mph. \$2,249; Gravelly Intl., 1 Gravelly Lane, Clemmons, N.C. 27012.

Spring-fed painter

Power Flo's Easy Trimmer (\$22) holds 4½ oz. of paint and lets you paint trim—with brush or pad—without constant dips into the paint can. To fill it, you pop a siphon tube on the tool, dip it in the paint, and pull back on the handle. To paint, squeeze the trigger.



Bang! You're nailed

A linear combustion engine drives the Impulse 300 Power Nailer from Paslode (2 Marriott Dr., Lincolnshire, Ill. 60015). Pull the trigger, and air and fuel (from a cartridge) enter the combustion chamber; on ignition, the explosion pushes the piston and drives a nail. \$850.



Spare parts

Jaws (hook and heel), springs (flat and coil), and adjusting nuts can be bought to renovate pipe wrenches. They are available for all quality standard-size (6- to 36-in.) wrenches, according to CMI Tool Group (26290 W. Eight Mile Rd., Southfield, Mich. 48034).



Planer-cum-sander

Your planer can double as a stationary power-feed sander with this \$70 Master Sander conversion kit. The kit fits many planers, including the Sears/Foley-Belsaw, and installs without planer-head removal, says the maker (Owen Tool Co., Box 35186 Kansas City, Mo. 64134).

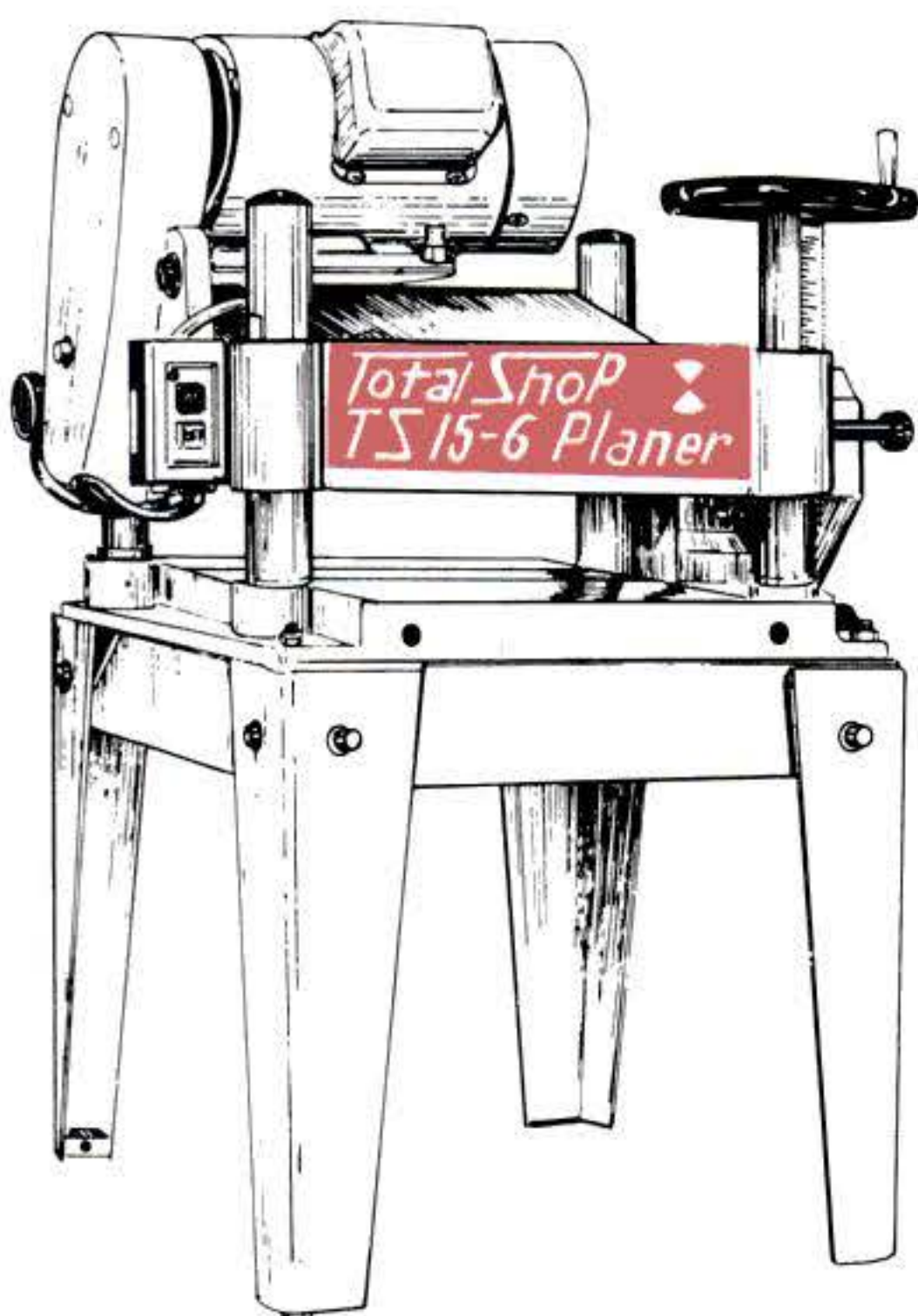
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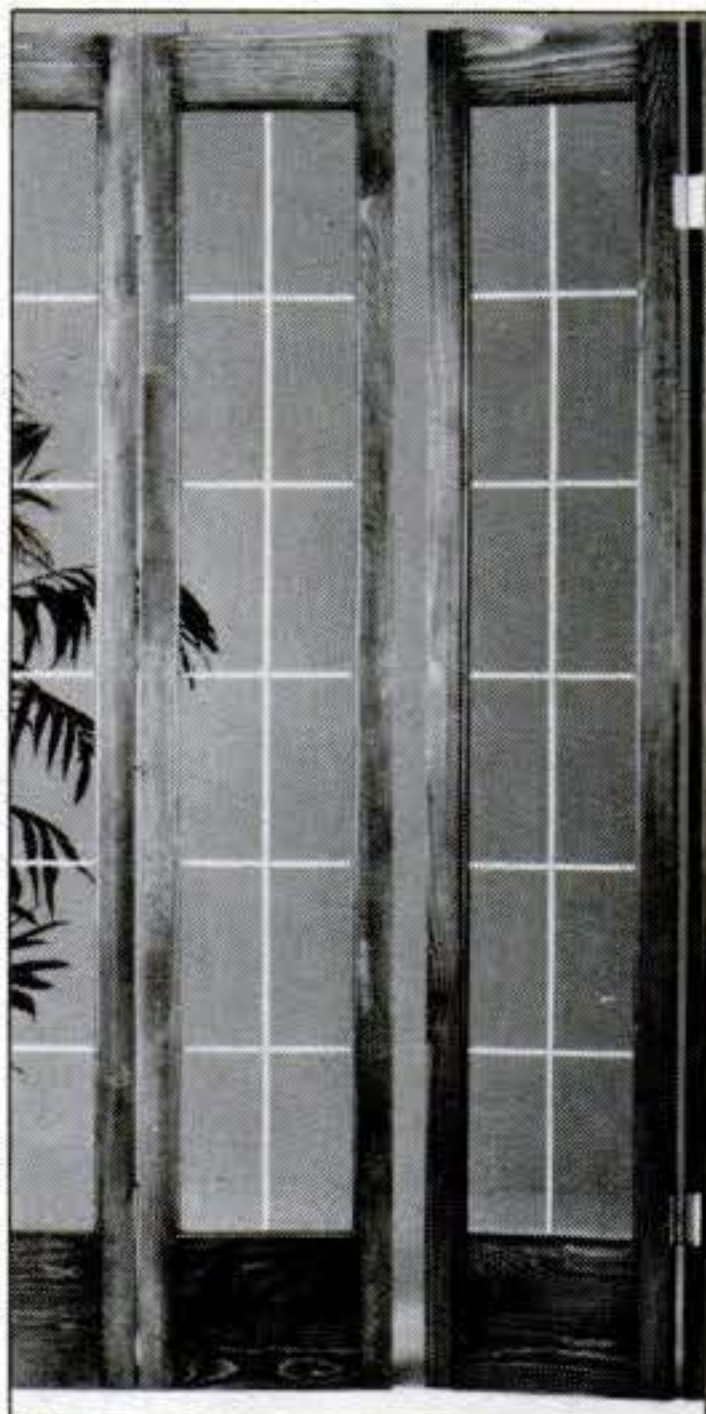
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What's New in Home Improvement

BY STEVEN ASHLEY

Solar water warmer

Set it on your roof, and hook it to your pipes: The sun-powered Solarus 2000 water heater will lower your utility bills, says Alternate Energy Resources (1477 Lomaland, Bldg. A, El Paso, Texas 79935). The 2-by-4-by-6-ft. unit has a 30-gal. tank and no moving parts. \$995.

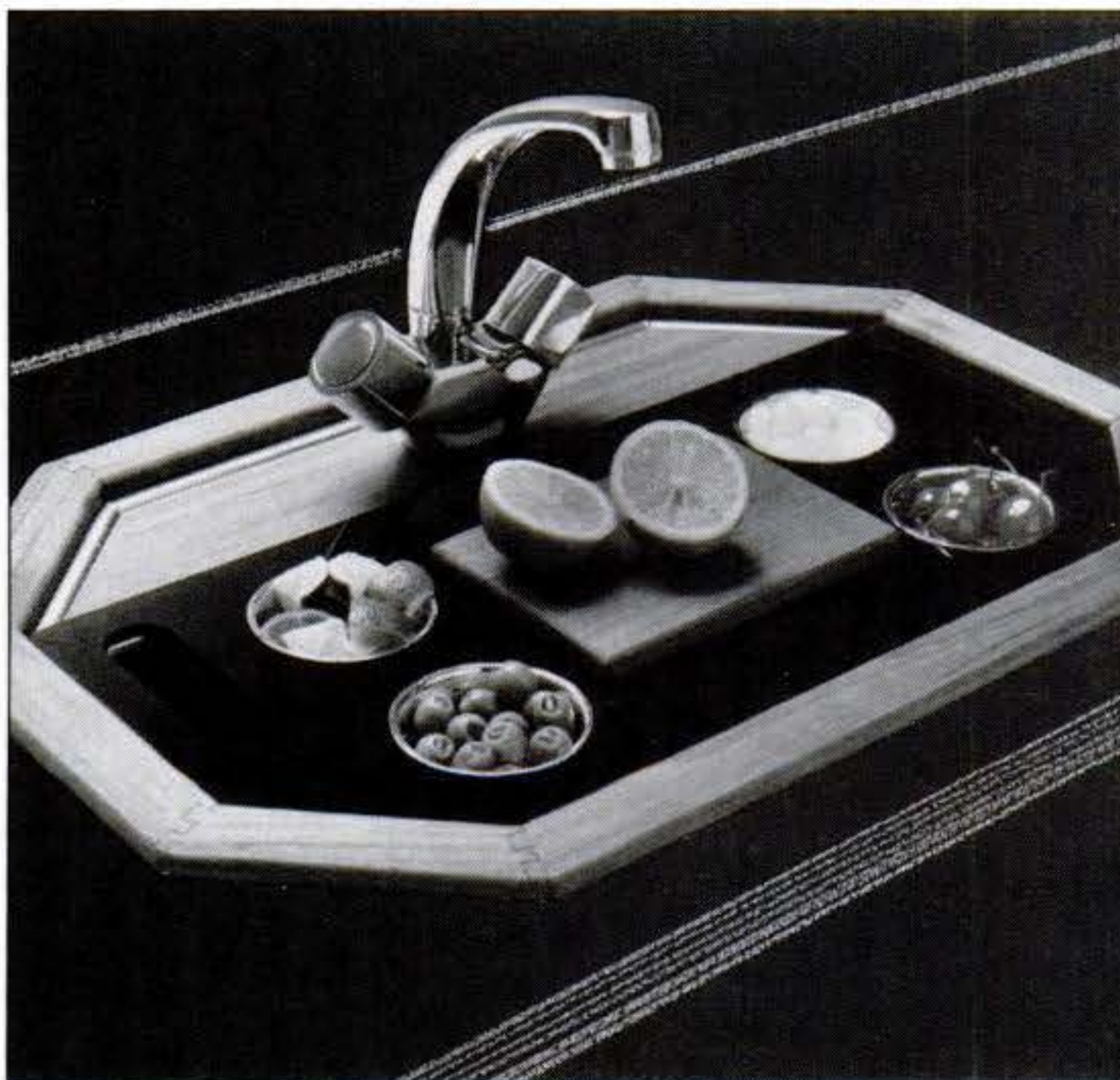


French doors

Almost any opening in a house interior—from 24 to 72 in. wide—can be elegantly enclosed by 80-in.-high French doors from Wing Ind. (Box 38347, Dallas, Texas 75238). La Door, in eight single- or double-folding models from \$100 to \$200, is pine, glass, and brass.

Gas-grill cart

Nordic Ware's portable gas grill now has a steel and red-wood cart for patio use. The \$175 propane gas unit features a lock-on cover, insulated base, stainless-steel burner, and aluminum construction. Northland Aluminum Prod., Hwy. 7 at 100, Minneapolis, Minn. 55416.



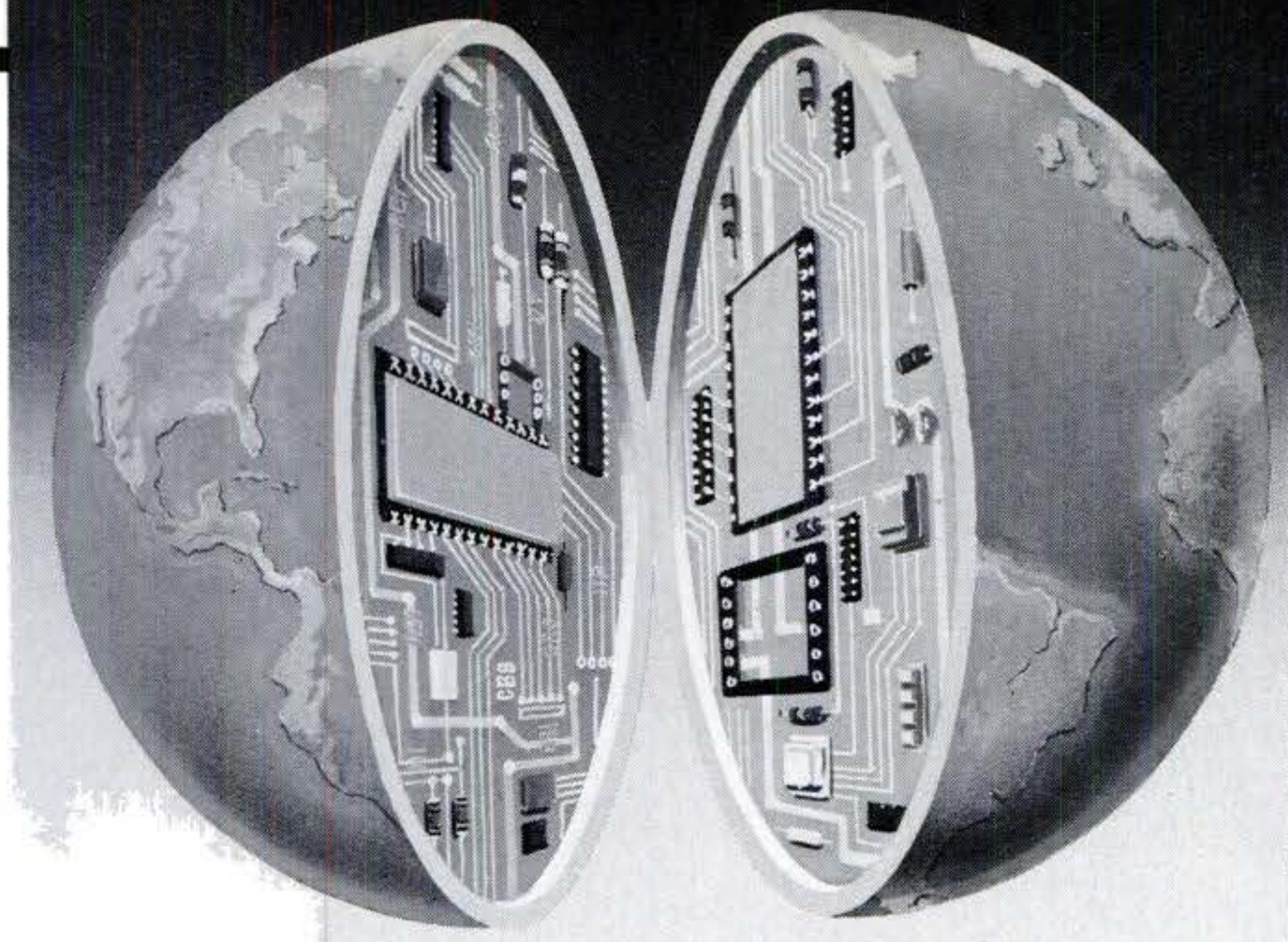
Bar sink with tray

The Bounty stainless-steel bar sink has an acrylic serving tray that fits atop the 22-by-15-in. basin. The tray, with a teak cutting board and four brass garnish cups, sits over a drain rack. Eljer Plumbingware, 3 Gateway Ctr., Pittsburgh, Pa. 15222; \$380 (faucet not included).



Sinking sink

This lavatory folds down so the entire family—kids and the handicapped included—can use the washbasin in comfort. Lift, a \$1,000 acrylic-coated stainless-steel pedestal, lowers to 18.9 in. From Villeroy & Boch (USA), I-80 at New Maple Ave., Pine Brook, N.J. 07058.



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What's New in Photography

BY ARTHUR FISHER

Aquatic 35

The Canon AS-6 Aqua Snappy is a fully automatic 35-mm camera that is waterproof to 33 ft. deep, fine for snorkeling and casual skin diving. It's shown with accessory sportsfinder and underwater close-up focusing aids. Price: \$160 (camera alone) or \$200 with accessory kit.



20-20 focusing

Nikon's N2020 35-mm SLR has two autofocus modes: a single-servo mode for stationary subjects and continuous-servo mode for action shots. It even autofocuses in the dark, with the SB-20 AF Speedlight shown. Price of the camera body is \$463; the flash costs \$199.



Dual spot meter

Want to spot-monitor both flash and continuous light with a single meter? Now it can be done with Sekonic's L-488 Digi-Spot meter. It offers a choice of 1° or 20° acceptance angles and claims an accuracy of one-tenth of a stop in continuous mode. Price is not yet set.



All-weather compact Wide, wide world

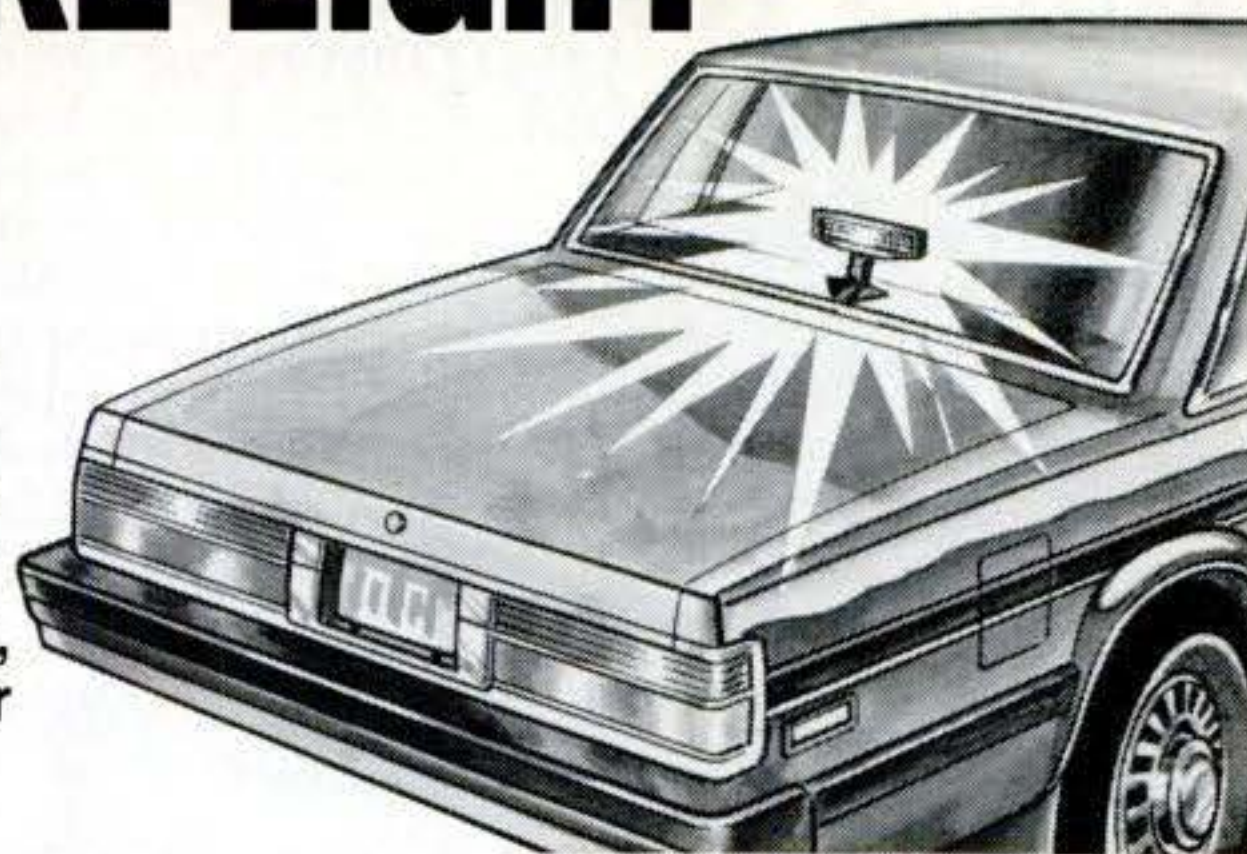
Totally automatic, weather-proof, and extremely light (8.1 oz.), the Olympus Infinity uses an active infrared autofocus system that maintains focus from 2.5 ft. to infinity. The built-in flash uses both a spot and an averaging light sensor. Price \$240.

For photos as wide as all outdoors, it's the Electropan, a panning camera (similar to the 35-mm Widelux) that produces a 2¼-by-5-in. photo on 120 film, for 140° coverage. Kornelius Schorlé, 25911 White Alder Lane, Laguna Hills, Calif. 92653; \$2,200.



New! EYE-LEVEL BRAKE LIGHT Gives YOUR CAR 1986 STYLING and SAFETY!

FITS ALL CARS (sedans, coupes, hatchbacks, station wagons), **VANS, PICKUPS—ANY YEAR, ANY MODEL—AMERICAN or IMPORTED**, with 12 volt system.



Astonishing Fact: Rigid testing by the federal government proved that the third brake light—mounted and functioning at eye-level to following drivers—**reduces rear-end collisions by 53%.**

Astonishing Fact: predictions by the National Highway Traffic Safety Administration (NHTSA) estimate that the eye-level third brake light will **prevent 900,000 rear-end collisions** a year.

Astonishing Fact: Estimates by the NHTSA predict that the eye-level third brake light will **prevent 40,000 personal injuries** a year.

Astonishing Fact: Use of the eye-level third brake light can reduce vehicle damage and repairs by almost 60%.

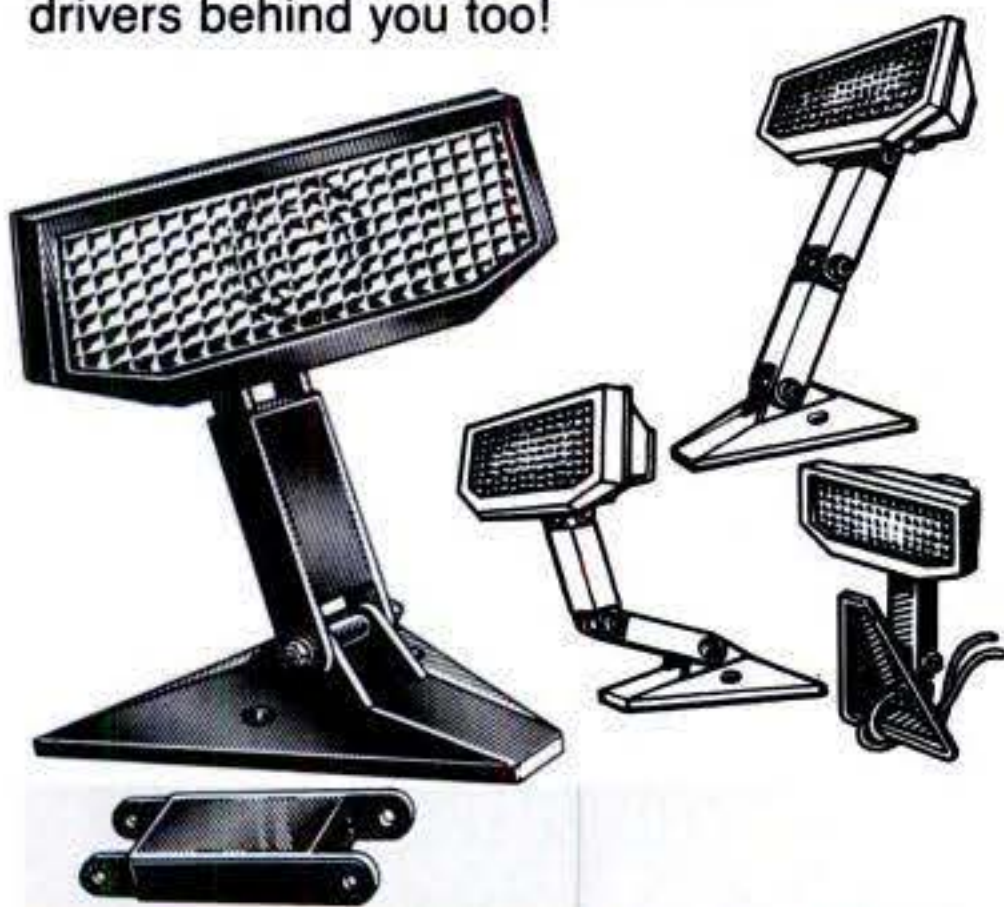
The overwhelming benefits of the eye-level third brake light demanded strong government action. So in the public interest...

Federal Safety Regulations Now Require Eye-Level-Mount Brake Lights On All 1986 Model Cars.

You owe it to yourself, to those who ride with you, and to those who drive behind you, to equip your car with this light as soon as possible.

Here's How It Works

Your third brake light is mounted at eye level, so it is highly visible to the driver behind you... and to the second and third drivers behind you too!



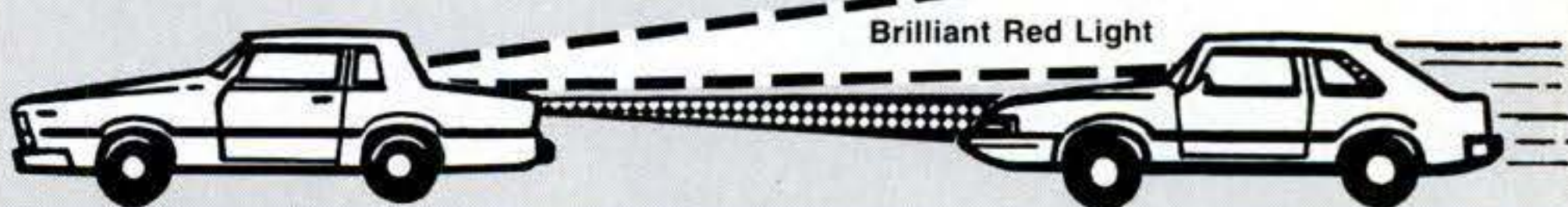
FAST, EASY INSTALLATION... FITS ALL CARS, TRUCKS & VANS

Bright red light turns on only when you press your brakes, so it's impossible to confuse with your turn-signal or tail lights

Extra mounting extension included... assures easy, perfect positioning in station wagon, pick-up, any vehicle

THIS YEAR'S MOST IMPORTANT AUTOMOTIVE ADVANCE

Third Brake Light Mounts at Eye Level
To Instantly Demand Attention



Drivers following you enjoy improved depth perception... night and day... and tail-gaters are warned to keep a safe interval.

A built-in logic circuit is programmed to turn on this light with your car's regular brake lights/and **with your brake lights only**—and that is very important...

This light is coordinated with your brake lights, and positioned in the center of your car, so that drivers behind you cannot confuse it with turn-signal or tail lights... even for a moment.

Installation of this light may even qualify you for a discount on your auto insurance.

Easy Do-It-Yourself Installation

Your light mounts easily **INSIDE** your rear window—just like new cars—where it is protected from harsh weather, car washes, theft and vandalism. No need for any nasty drilling into your car body. NO wire cutting, stripping or taping either. Special splices are included to let you connect light wires to your brake-light wires... instantly... with any pliers!

Fits ALL Cars, Trucks, and Vans

The universal mounting bracket, pivoting joints, and extra mounting extension make it easy to position your light perfectly. You will enjoy easy installation in any sedan, hatchback, station wagon, pick-up truck, van, or any other American or imported vehicle with a 12-volt electrical system. Your light has a big 6 $\frac{3}{4}$ " wide x 1 $\frac{1}{8}$ " high red lens, and wiring, splices and easy-to-follow illustrated instructions are included.

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J.C. Whitney & Co. stands behind every brake light we sell. Each light comes with our iron-clad promise to you: **Complete Satisfaction or Your Money Back.** If you are not completely delighted with your brake light... for any reason... simply send it back, and we will cheerfully replace it, or promptly refund your money, whichever you prefer.

We believe every car on the road should be equipped with an eye-level third brake light. So we are making them available now... for only **\$8.95** each, plus only **\$1.00** for shipping your brake light anywhere in the United States. At this low price, you can order one now for every vehicle you own.

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When split-seconds can save life and limb—and reduce property damage too—it pays to have an eye-level brake light in your car. **Get this valuable protection for your car now.** Simply fill in the coupon below, and send it in with your check, money order, or credit card information.

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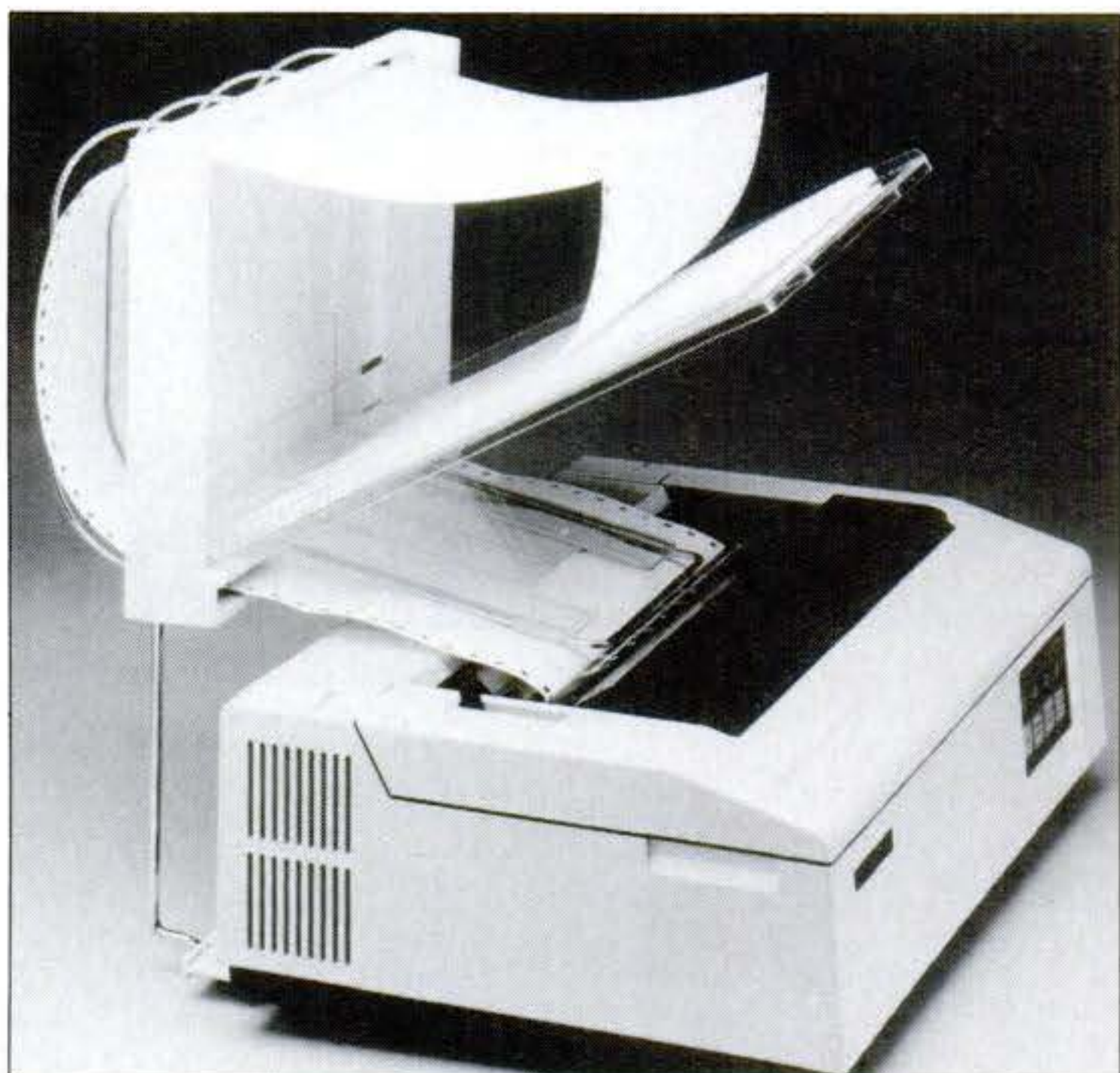
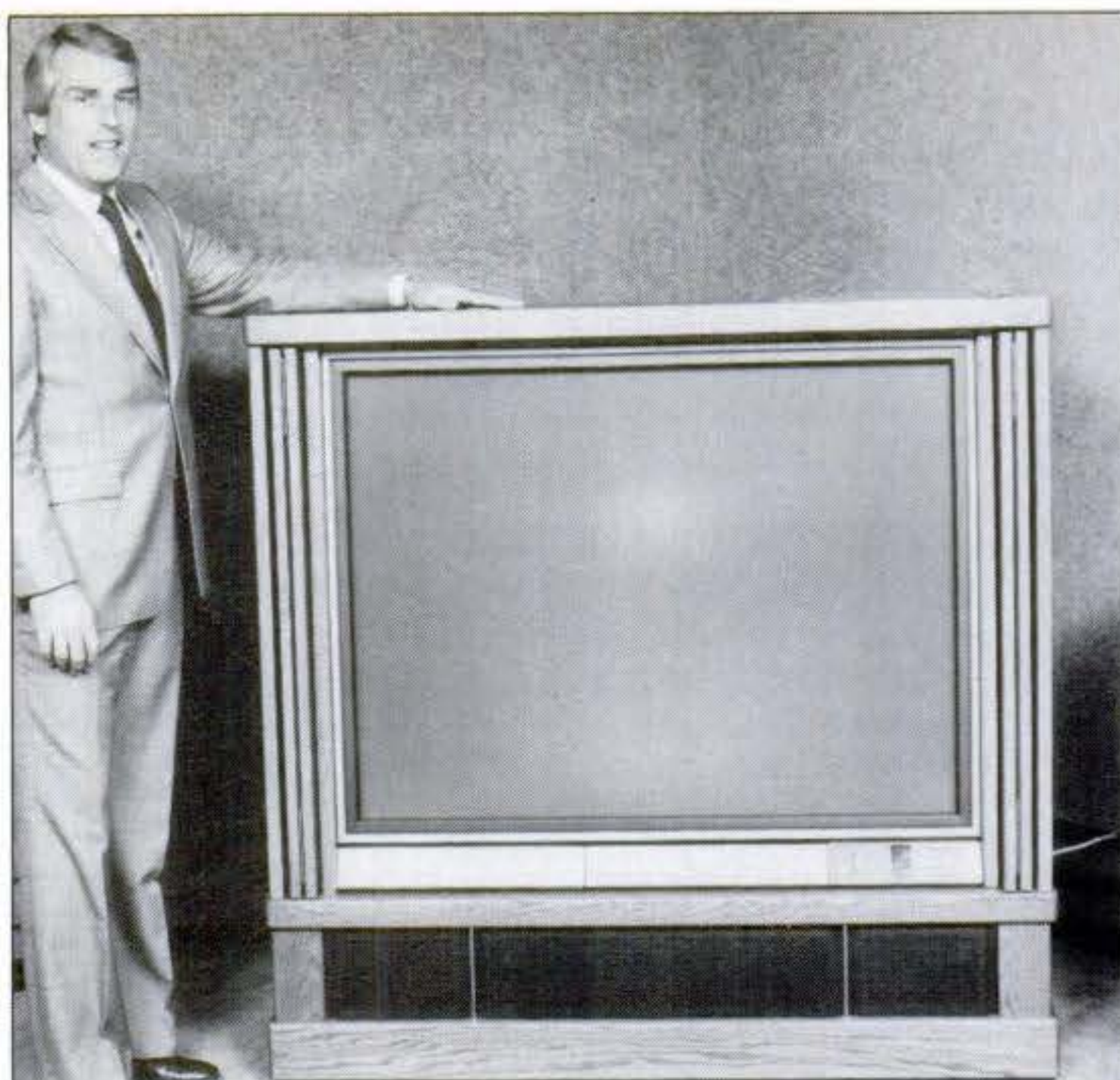
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What's New in Electronics

BY WILLIAM J. HAWKINS

Big big-screen

That's not a small man—it's a very large television. In fact, with its 50-in. diagonal picture, it's the world's largest rear-projection TV set, according to the maker, Mitsubishi. The set comes with a cable-ready tuner, remote control, and built-in stereo. It costs \$3,600.



Up and away

No room in the back? No space underneath? Then feed the computer printer's fan-fold paper up into Top Deck 80. As pages are printed, they pass up into the tray and are refolded. Made by AmeriPac (3420 Dundee Rd., Northbrook, Ill. 60062), it's \$40; with printer stand, \$60.

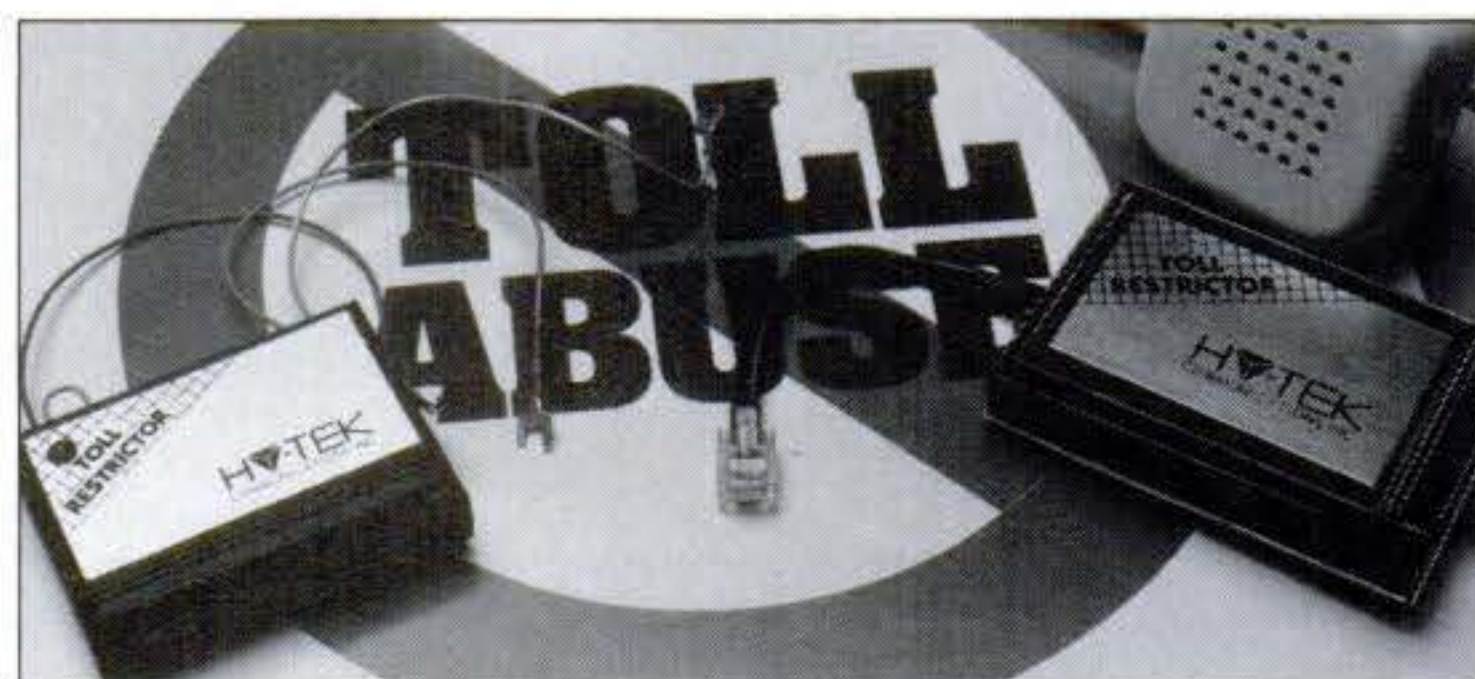
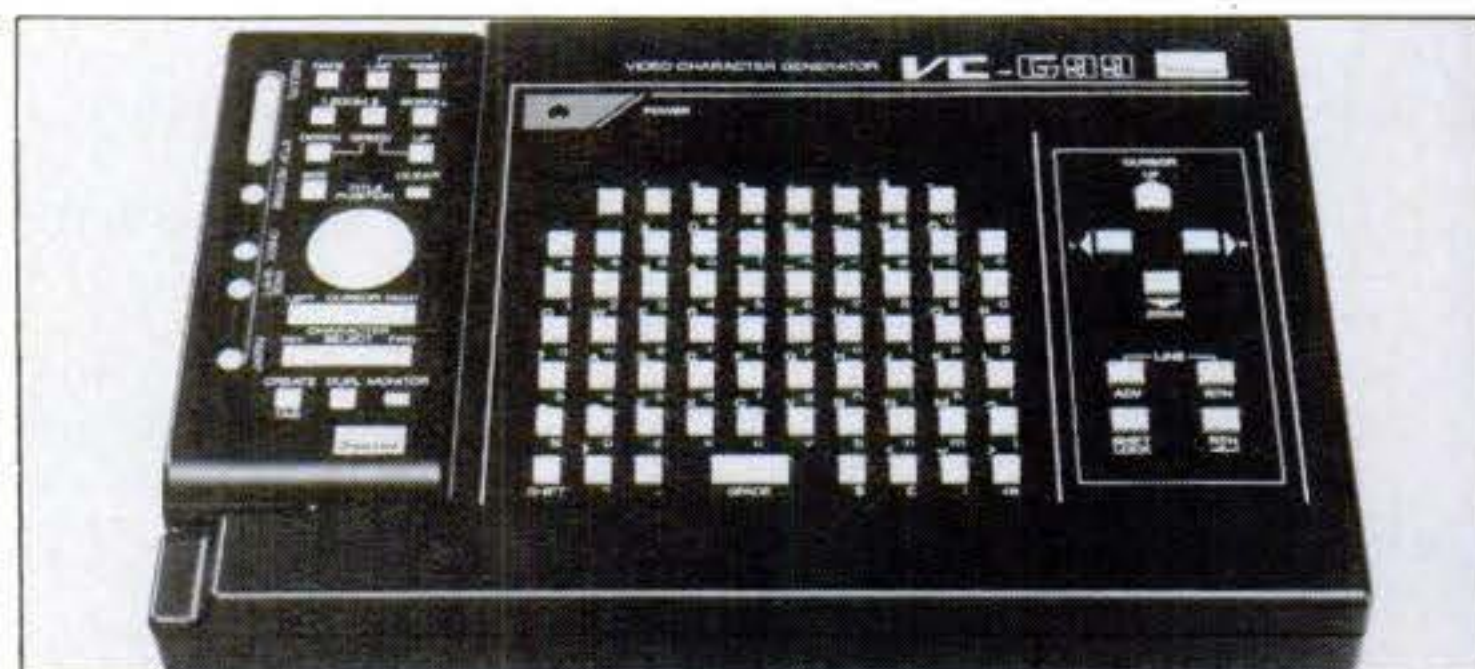
Tape titler

Give your home movies a professional look. Attached to your video camera, this portable character generator from Sansui Electronics adds titling in four languages—English, Spanish, German, and French. Text can be zoomed, positioned, or scrolled over a scene. \$350.



Hands-free headset

You just speak to communicate with General Electric Co.'s all-in-one walkie-talkie. A voice-activated microphone and all controls are built into the headphones. Made for recreational and commercial use, the 49-MHz unit is \$30.



The wet looker

Home movie making has just hit a new low—as far down as 140 ft. Sony's airtight Marine Pack holds the company's Handycam 8-mm camcorder for underwater shooting. The pack contains a wide-angle lens and an external piezoelectric microphone. Price is not set.

Call checker

First dial your secret three-digit code. Now you can make long-distance calls from your telephone. If anyone else tries—without the code—the \$70 Hy-Tek Toll Restrictor breaks the connection. R. K. Burtchell Co., 516 S.E. Morrison, Portland, Ore. 97214.

Radio Shack Introduces the First High-Performance Satellite TV System You Can Install With Ordinary Hand Tools

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What's New for Your Car

BY JACK KEEBLER

Dual-blade wipers

Double-bladed wipers spray washer fluid between their twin edges for maximum cleaning, says VDO AG (Sodener Str. 9, 6231 Schwalbach am Taunus, W. Germany). Three jets centered on the wiper frame spread the fluid along the full length of the anti-lift blades.



Sun-roof solar power

Up to 20 W of solar-generated 12- or 24-V electricity will be available to some car owners in Japan with the Amorton sun roof, developed by Sanyo Electric. The amorphous solar battery sun roof can power accessories or can be used as a backup for the car's charging system.



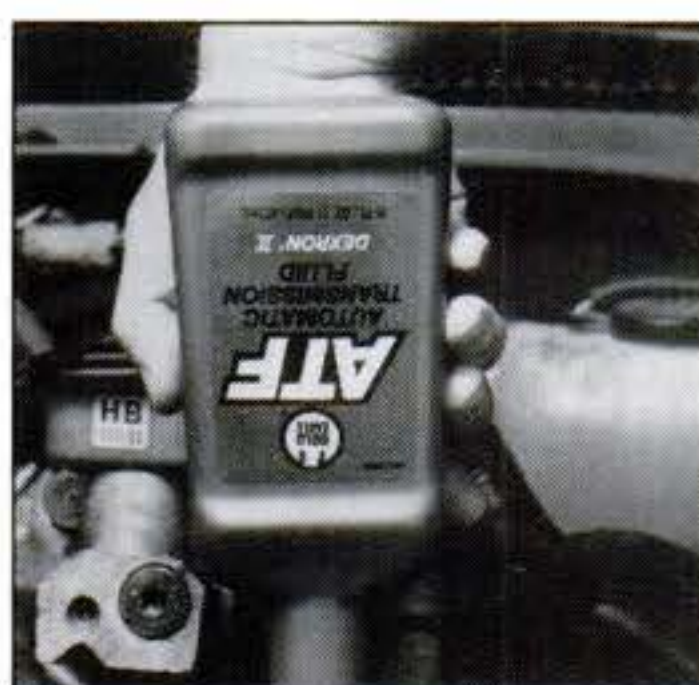
Washer-fluid kit

Convert-A-Bottle kit includes hose, cap, and tie-down strap so that a gallon windshield-washer-fluid bottle becomes the reservoir—in the trunk. Now there's no need to lift the hood or store unused fluid. Markus Products (16860 S. Oak Park Ave., Tinley Park, Ill. 60477); price: \$6.



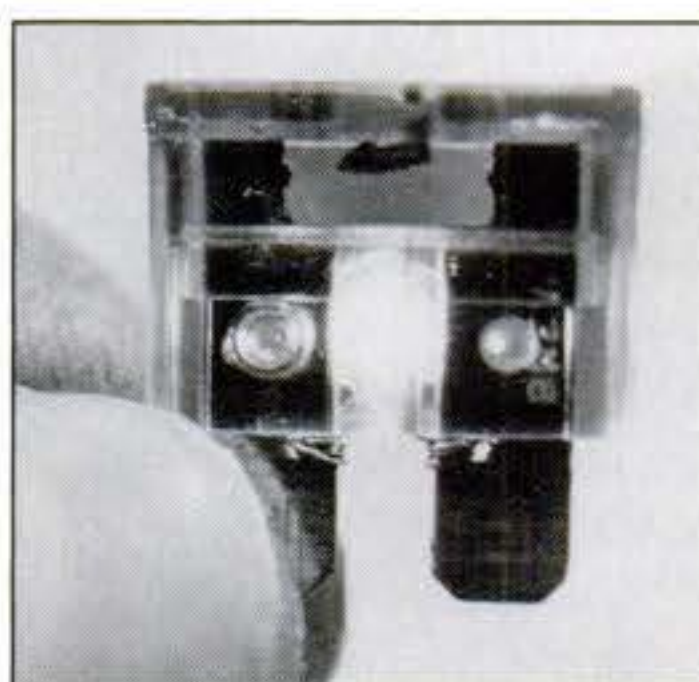
Easy-pouring bottle

Pouring automatic transmission fluid into a narrow auto transmission fill pipe can be messy. But the spout cap on Gold Eagle's Dexron II container makes it easy and eliminates the need for a funnel. And the bottle is re-sealable, so unused fluid is no longer a storage problem.



Blow-glow fuse

This fuse glows when it blows, claims Safeguard Fuse Co. (63 Woodham Lane, New Haw, Weybridge, Surrey KT15 3ND, England). The plastic body houses a tiny bulb wired between the fuse blades in parallel with the fuse element. That makes it easy to spot a problem.



On-the-road TV

Sony says its video entertainment system for RVs, limousines, and mobile homes provides a clear, stable picture that rivals home TV. Designed exclusively for vehicular use, the \$390 tuner uses two antennas to automatically compensate for signal variations.

Bed extender

Pickup owners can stretch their hauling capacity with Xtend A Bed. Two suspension towers distribute the load's weight (up to 300 lbs.) across the back of the truck. The \$300 extender stores under the bumper, says Ross Mauer Inc. (2947 West Ave., Gulf Breeze, Fla. 32561).



WORKMAN'S COMP.

One nice thing about a big Chevy Pickup: the same powerful engine, the same girder-beam front suspension and tough double-wall steel construction in critical areas that get you through a tough day's work, can also get you away *after* a tough day's work. Cap the back of a Chevy and have fun. You've earned it.

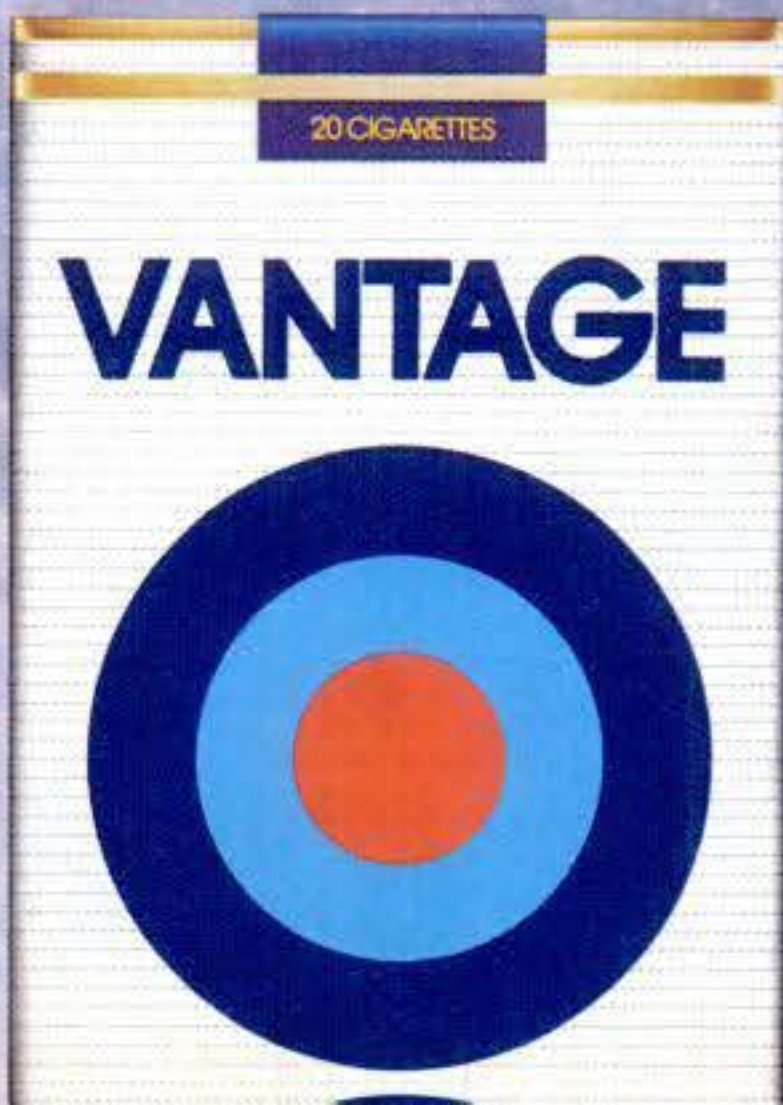


...s get it together... buckle up.

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9 mg. "tar", 0.7 mg. nicotine av. per cigarette by FTC method.

SURGEON GENERAL'S WARNING: Quitting Smoking
Now Greatly Reduces Serious Risks to Your Health.

What's News

In April we began a two-part series on hypersonic-aircraft development with Tom Heppenheimer's article on new-generation jet engines. This month we continue with Jim Schefter's piece on the other parallel development program: airframe design.

The clear line that separates these areas in most development programs is not so clear in this one. That's because at the extreme speeds contemplated, the entire airframe becomes part of the engine's intake configuration. So engine and airframe must be designed as a unit. That's only one of the fascinating areas Jim talks about in his piece beginning on the next page. The striking cover painting, showing several of the leading designs now being considered, is by Dean Ellis.

Making the news?

It's rare for a science writer to actually participate in a "eureka event"—the moment when someone comes up with an idea that leads to technological innovation. But according to Dr. Martin Annis, creator of the Model Z airport X-ray system, that happened when he was talking to Steve Ashley of the PS staff last year. Steve was doing research for our November cover story on terrorism in the air. During a telephone conversation Steve asked Dr. Annis about dual-energy X-rays, an advanced technique that can locate specific atomic elements, such as mercury in a blasting cap. That question, says Dr. Annis, set him to thinking about how his own company's technology might be adapted to detect plastic weapons in airline baggage.

A few weeks ago Steve got a call from Dr. Annis, inviting him to come up and see the new machine that grew out of that incident. It's a real advance in the art, and Steve gives all of the details in his piece in this issue.

Round-the-world this summer?

The cover of POPULAR SCIENCE in September 1984 contained a picture of Burt Rutan's incredible Voyager, a

spindly 3,000-pound airplane with a wingspan as big as a 727's, designed for one purpose: to fly around the world without stopping or refueling. The attempt had originally been scheduled for the spring of 1985. That slipped because Rutan couldn't get the corporate backing he needed. But the plane has been flying—some 29 flights for a total of 84 hours air time so far. Actual performance figures, according to Rutan, are slightly better than anticipated, so the craft now has a calculated range of 28,000 miles—3,000 more than necessary to circle the globe.

Rutan is planning to schedule several two- to four-day flights over the next few months, then this summer try a 13,000-mile seven-day closed-course flight off the coast of California. If that goes well, he hopes to get the necessary money and make the round-the-world record attempt by late summer.

It will be an incredible flight. The plane is scheduled to leave Edwards Air Force Base, in California; cross the Pacific Ocean to Hawaii; continue toward Australia; cross the Indian Ocean to the southern tip of Africa; and proceed on to the coast of Brazil, up the Caribbean Sea and Gulf of Mexico, across Texas, and back across the southwest to Edwards. At the beginning, with 8,000 pounds of fuel aboard and both engines running, speed will be about 130 knots. When some fuel has been burned off, one engine will be shut down, and speed will drop to between 70 and 80 knots. The trip will take just under 12 days.

Glassy metals

In December of 1982, POPULAR SCIENCE carried an article on metals cooled from a molten to a solid state at a rate of a million degrees a second. That neat trick is achieved by squirting a stream of molten steel at a rapidly spinning drum. It comes off the bottom of the drum as a thin strip that looks like foil.

Why do that? Metals processed that

way are amorphous, similar in structure to glass. The normal crystalline structure does not appear. Such glassy metals have useful properties. One of the most interesting: They are extremely easy to magnetize. Build a transformer with one, and the usual losses are slashed; not as much of the electrical energy is needed to constantly demagnetize and remagnetize the core 120 times a second with each flip of polarity. Researchers have estimated that if all transformers in the country were made with glassy-metal cores, we'd cut the annual power losses by perhaps 20 billion kilowatt-hours.

We're about to find out if that is true. General Electric has replaced silicon steel in some power-line transformers with glassy metal. The Electric Power Research Institute is about to put 1,000 of them to test, and we should know results soon. Meanwhile, General Motors plans to switch to starter motors made with glassy metals in two years or so.

Honors

I'm happy to be able to report that POPULAR SCIENCE Science and Technology Editor Arthur Fisher has just won the prestigious annual science writing award of the American Institute of Physics. Arthur's "Death Star," which appeared in PS last June, was a strong contender for the honor. But he ultimately won for another piece, called "Chaos: The Ultimate Symmetry," which appeared in the January/ February issue of *Mosaic*, published by the National Science Foundation. It's a well-deserved honor; Arthur is one of the country's outstanding interpreters of science and technology for the general public, as his many other awards over the years testify.


Editor-in-Chief

Spurred by advances in engine design, materials technology, and supercomputing, a radical new kind of airplane is being developed. Like the concept craft from Lockheed at right, it could flash through the fringes of space at hypersonic speeds.

Space plane —coast to coast in 12 minutes

By JIM SCHEFTER

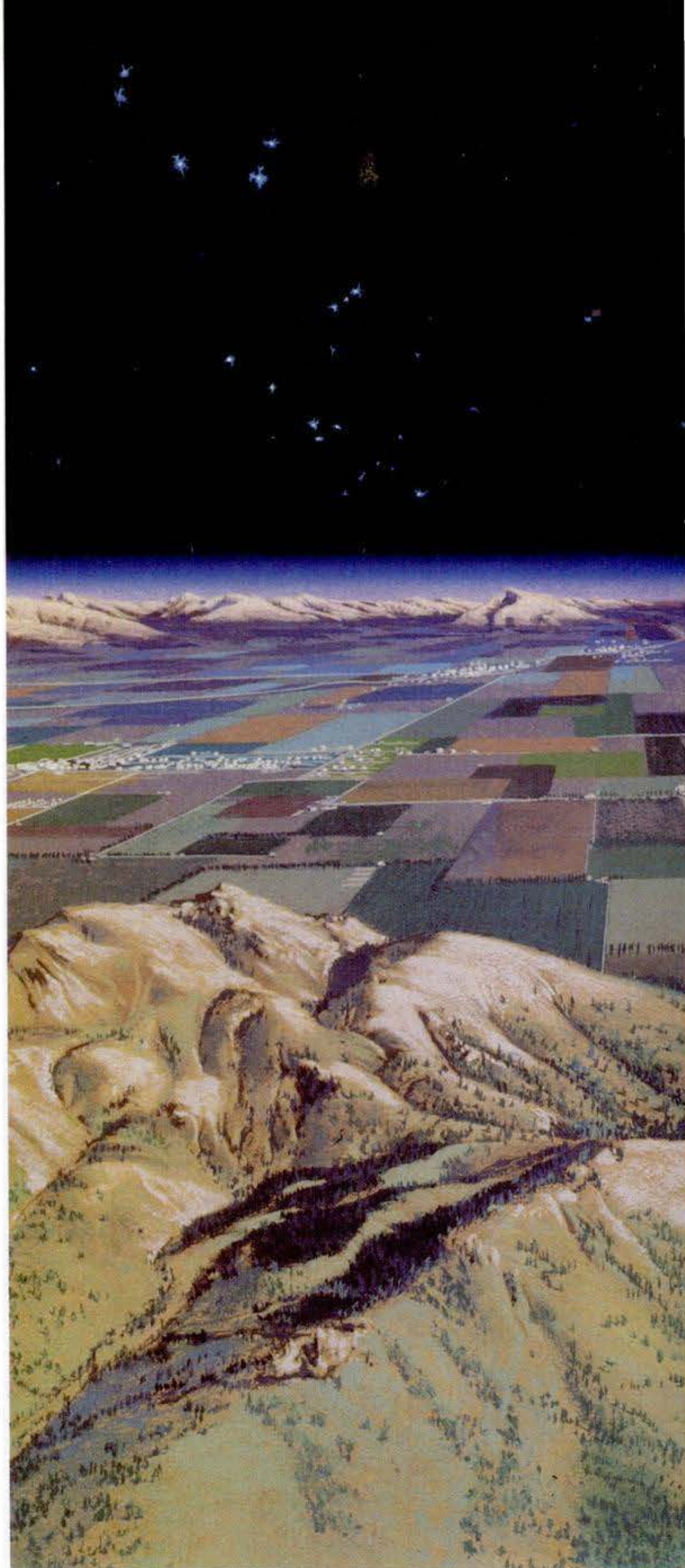
It's 10 a.m. at New York's Kennedy Airport: "Global Airways flight 2005 now departing from gate 11," says a voice over the PA system.

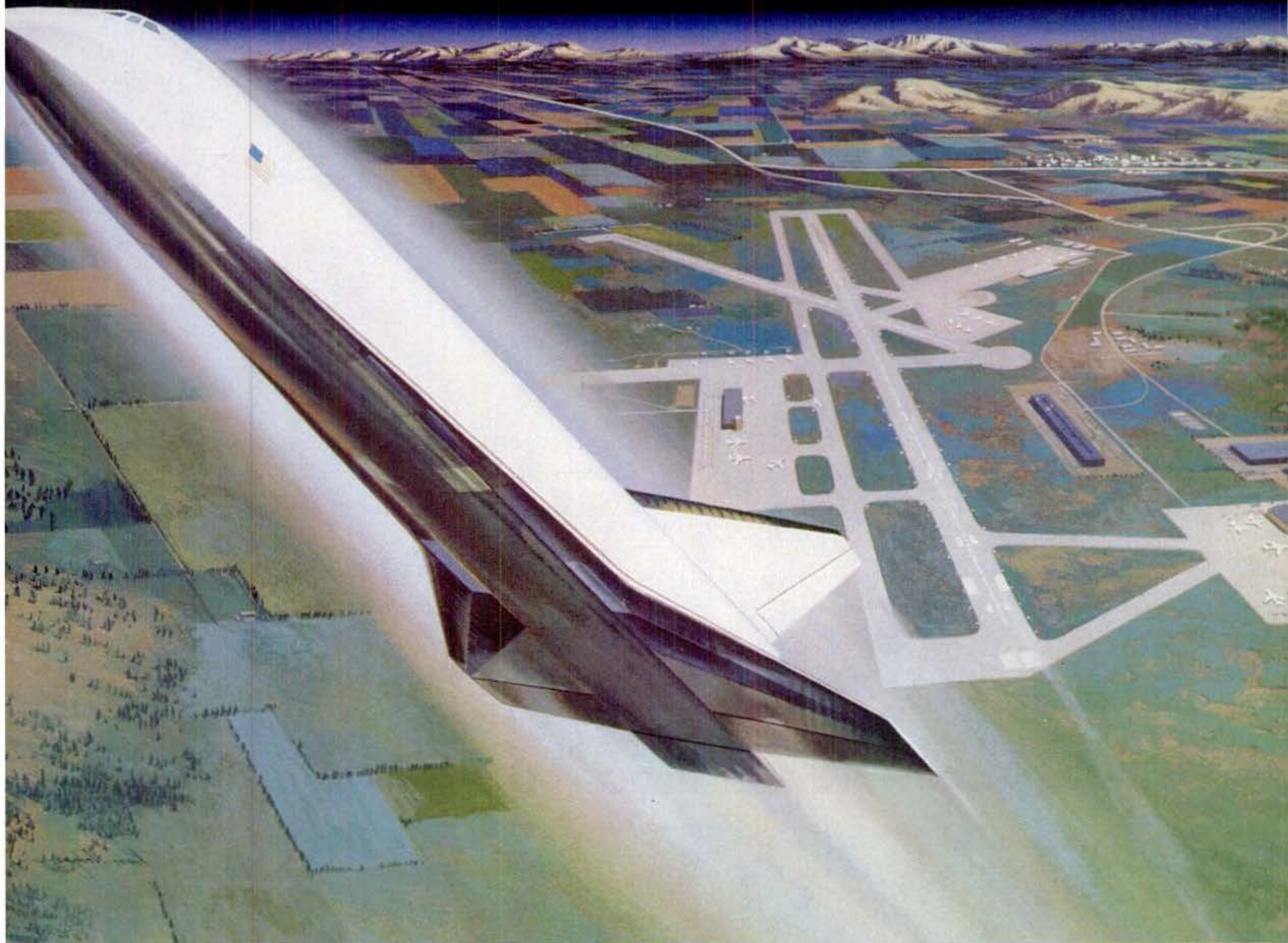
At Los Angeles International Airport, it's 7:42 a.m. when the following message is heard: "Global Airways flight 2005 now arriving at gate 17."

Elapsed time from coast to coast: 12 minutes; gate to gate: 42 minutes. That's 15 minutes climbing, 15 minutes descending, and 12 minutes in between. Add another 20 to 30 minutes for the en route cruise at altitudes more than

30 miles high, and the same flight could have landed in Hong Kong or Sydney, Australia.

That incredible aircraft, cruising just below the edge of space at speeds between Mach 15 and 25, is the aerospace-plane, or transatmospheric vehicle. It's no engineering pipe dream. President Reagan, in his February State of the Union address, said "we are going forward with research" on the visionary plane that has been dubbed "a new Orient Express." The National Aeronautics and Space Administration (NASA) and the Pentagon, already backed by a budget commitment from the White House, expect to begin flying an X-type (experimental) transatmospheric research plane





within five or six years. It will fly somewhere between Mach 12 and Mach 25. The plane won't carry more than a single test pilot. But it may begin carving a path through the fringe of space for commercial airliners—and perhaps orbiting transports—of the 21st century. As last month's "Scramjets" article indicated, a Mach 5 or 6 plane could be attainable with air-turbo-ramjet engine technology, but present thinking is to leapfrog that stage.

Turning the dream of hypersonic flight into reality, say experts involved in the program, is possible because of recent breakthroughs in both engine and materials technology and in the use of supercomputers. I talked with the

key people pushing for aerospaceplane development in the U.S. and discovered that both research and development and the government's quiet planning are well advanced.

At the same time, the British government's spaceplane program, less ambitious than ours, moves quietly forward under tight security wraps. It is called HOTOL (for horizontal takeoff and landing). In February, the Trade Ministry authorized \$4.1 million more for HOTOL studies.

"We have a whole new generation of materials, propulsion systems, and large computers under development or already in use at various research facilities," a highly placed

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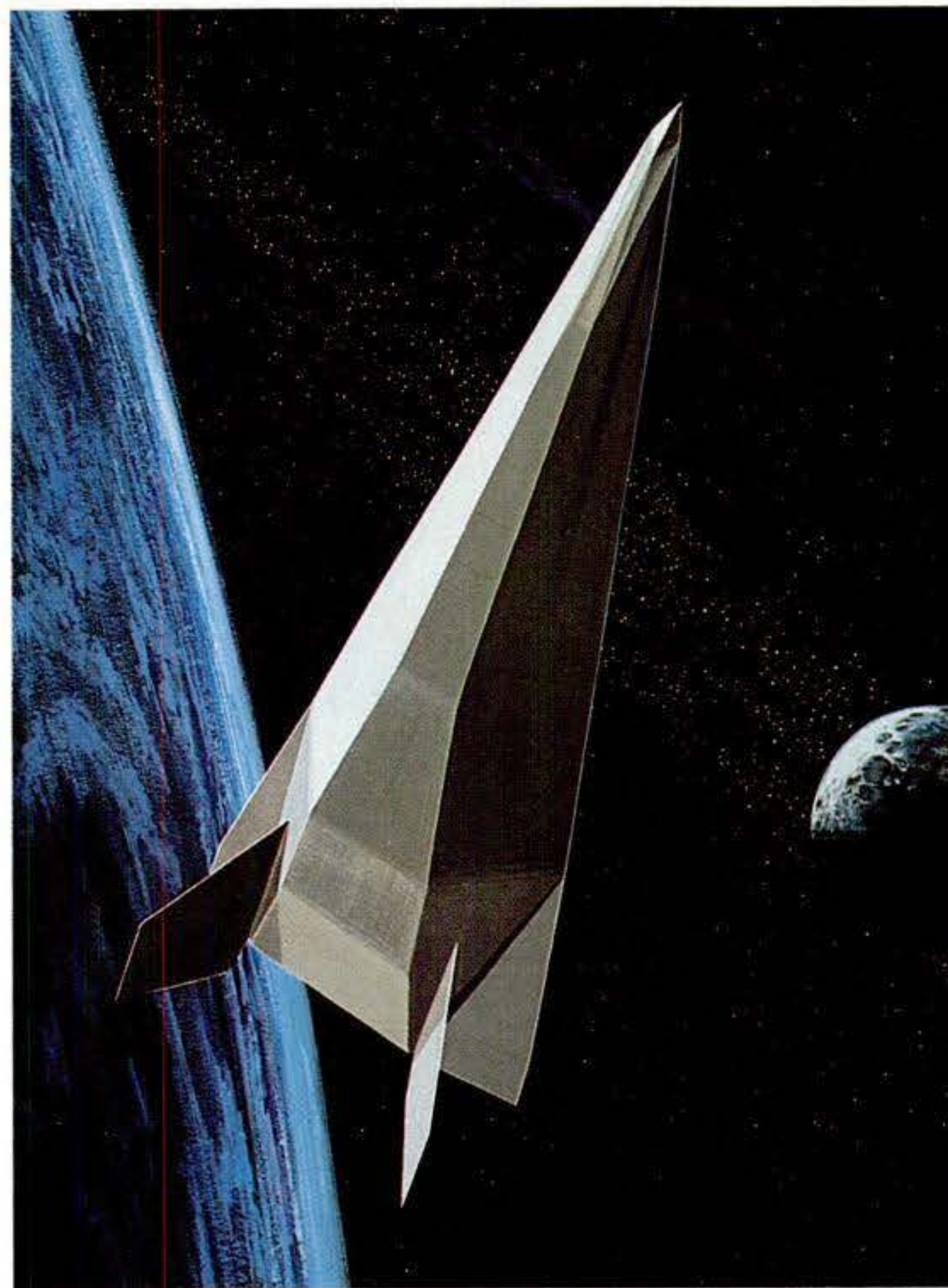




Shuttle-like Rockwell aerospaceplane (above) uses a two-stage system: A reusable launch undercarriage with its own engine assists takeoff, then drops away. Needle-nosed McDonnell Douglas concept (above right) is shown in Earth orbit, 1,200 nautical miles up. The strategic/reconnaissance aircraft could fly at Mach 12. Boeing's transatmospheric vehicle design (below left) is carried, with its massive fuel tank, atop a 747 before release into hypersonic flight.

White House expert, who asked not to be named, told me. "All these are reaching maturity, and there is the potential for integrating them into a flying vehicle. But the reality is that there is great difficulty in making the formal decision. It's all tied in with the budget process. The spaceplane will fly so long as it doesn't inhibit space-station development."

There are, however, some negative voices in the aerospaceplane chorus. Some critics believe that we should be aiming first at an intermediate supersonic passenger plane,



such as the 1,700-mph second-generation Concorde the French are interested in building. One naysayer is industry expert John Steiner, who retired in 1983 as a vice president of Boeing and then served as chairman of the White House Aeronautical Policy Review Committee. He believes that airlines would go for a superfast supersonic aircraft to service the Pacific Rim, but that the real interest in hypersonic aircraft is military, not commercial. And John Pike, of the Federation of American Scientists, has said that the aerospaceplane makes sense for the backers of the Strategic Defense Initiative (the Star Wars plan) because it would lower the cost of space launches. But he questions whether there is really any other economical use for it.

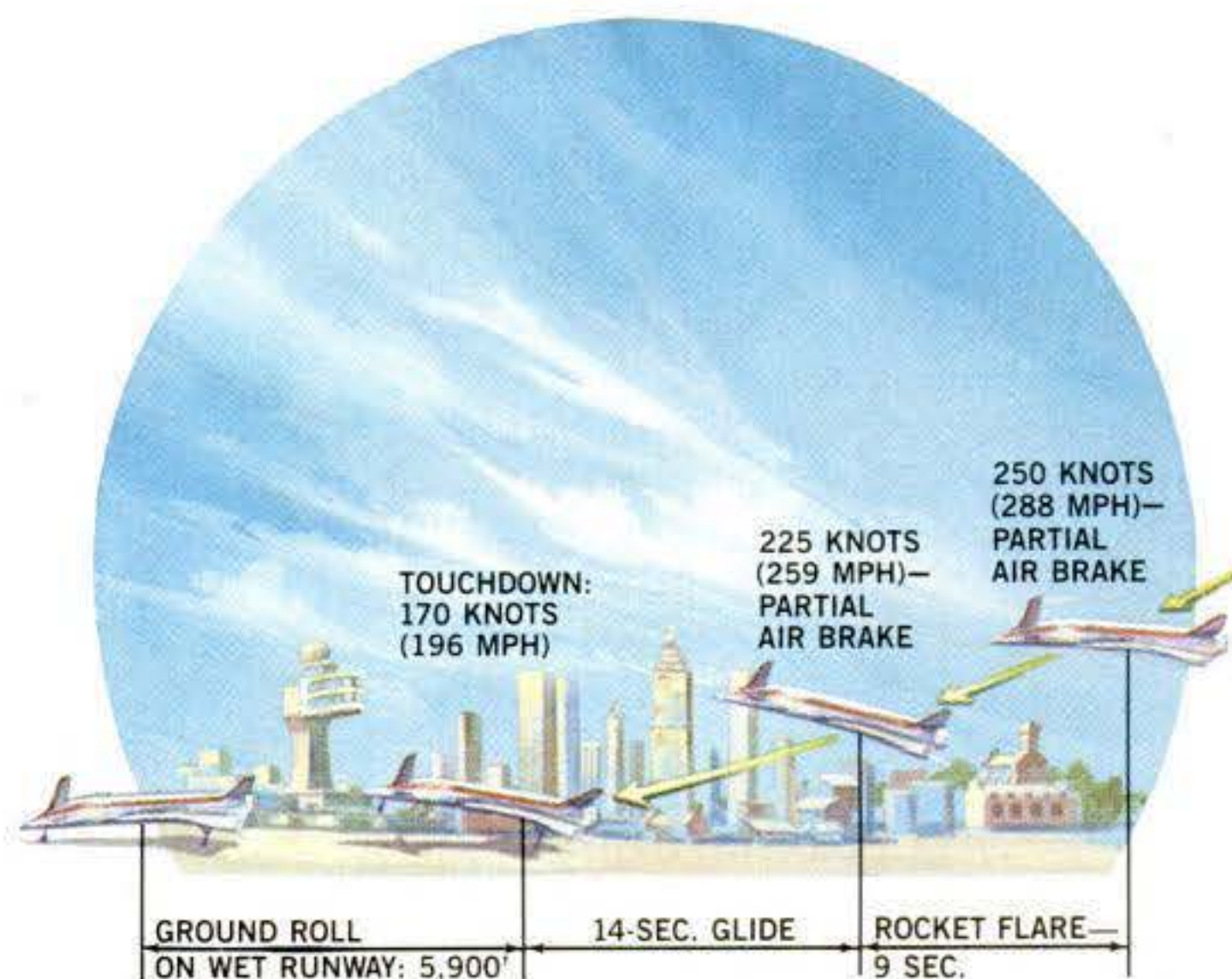
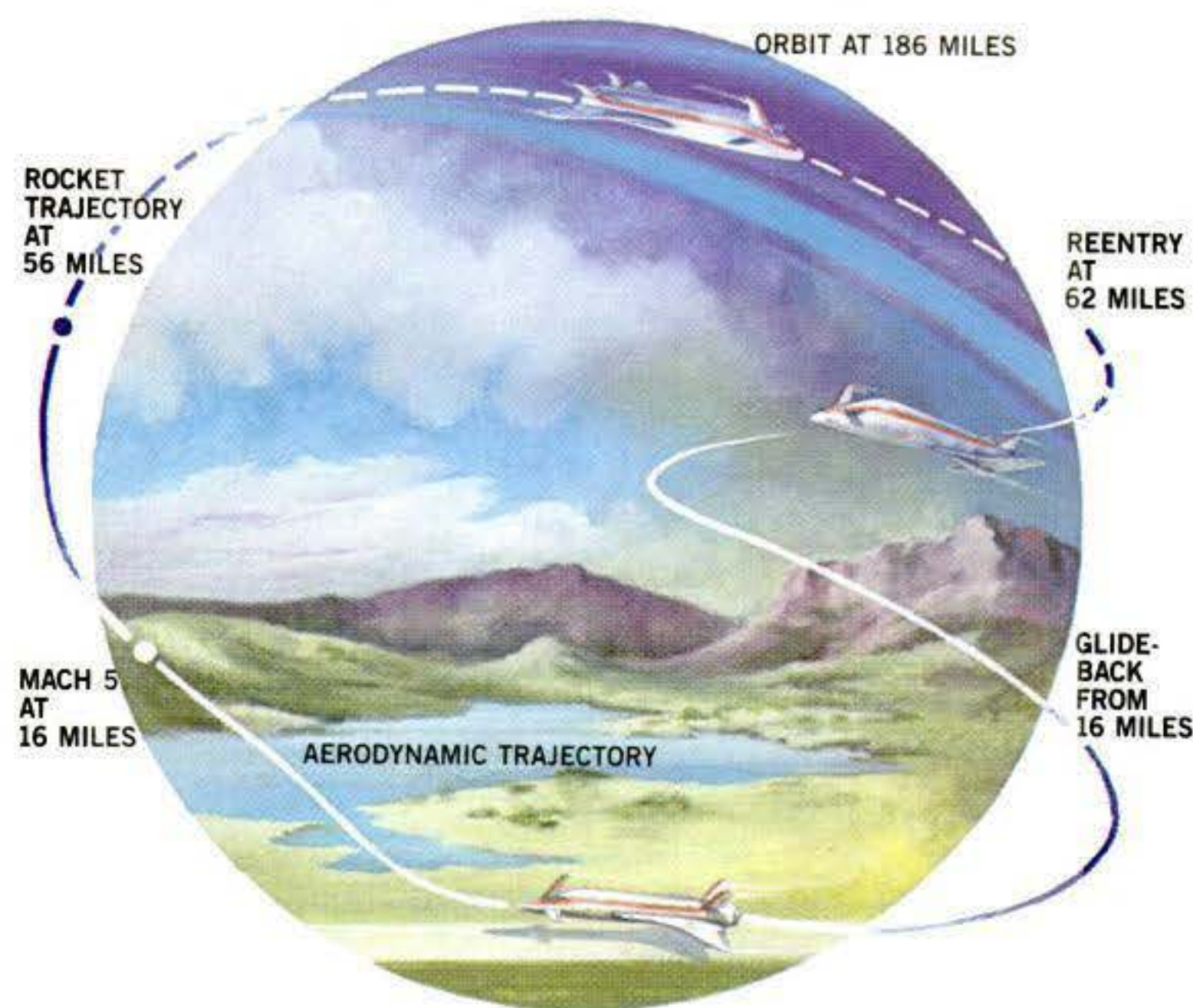
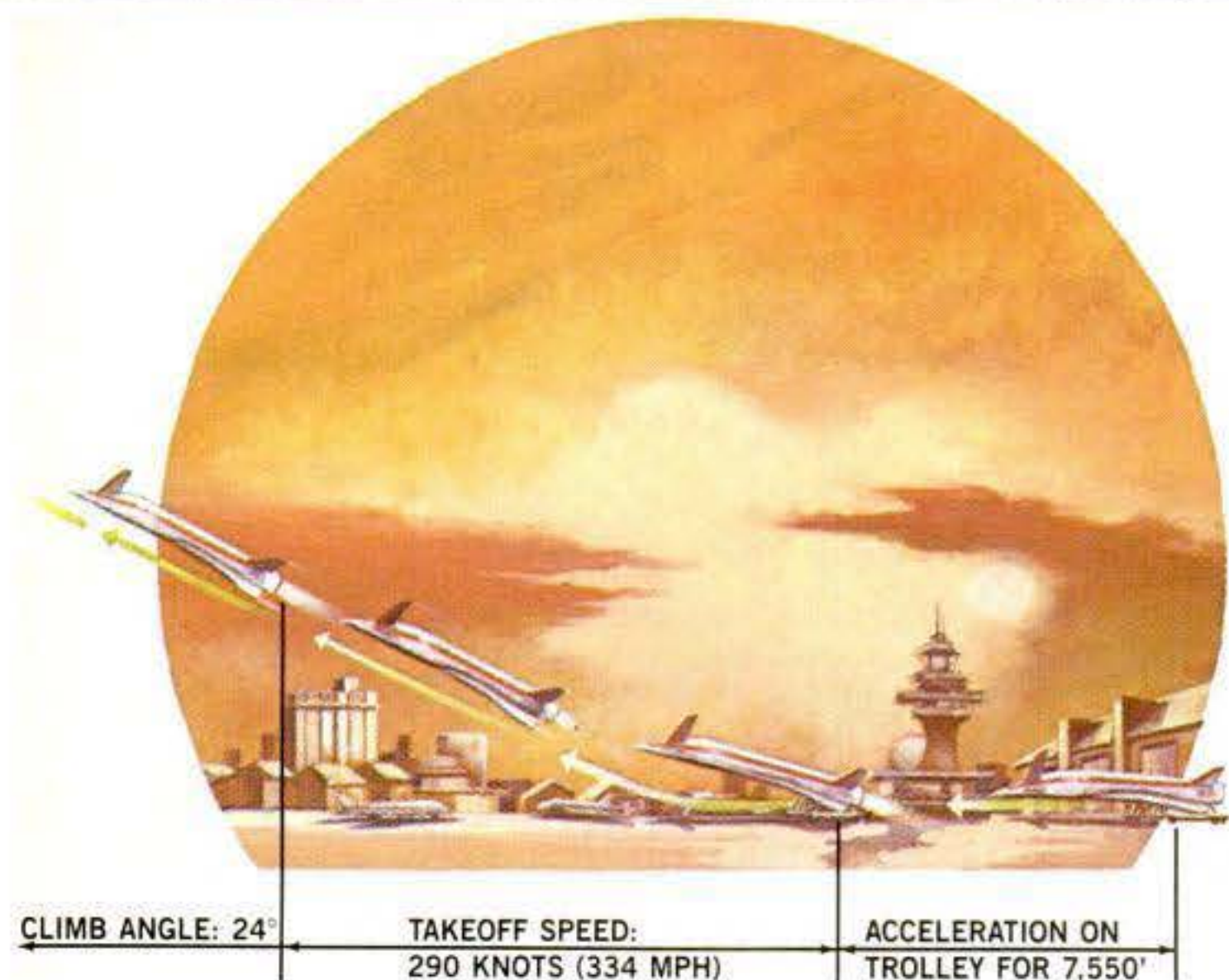
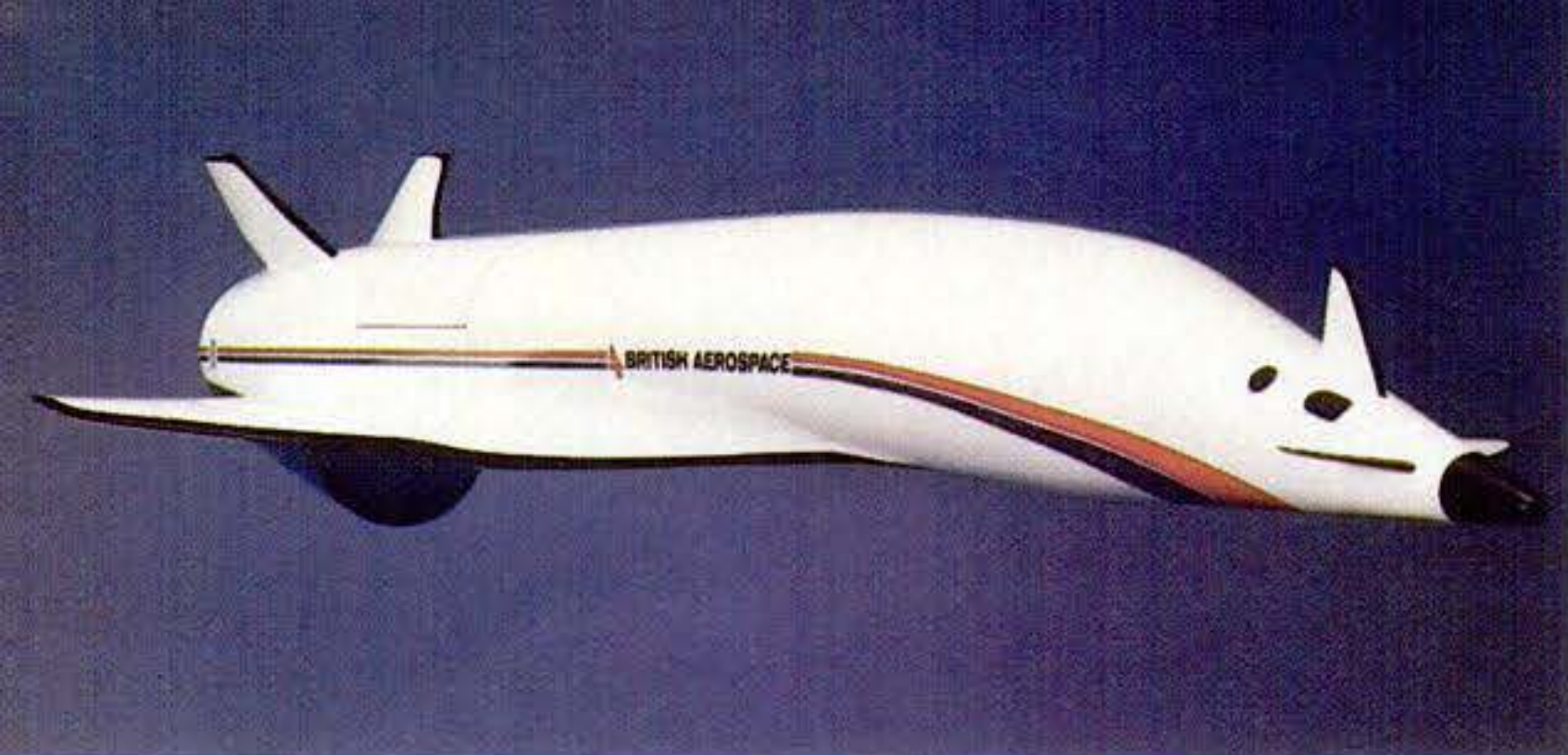
Nevertheless, much of the basic research needed to go ahead with a hypersonic research aircraft is in hand, most of it done at NASA's Langley Research Center, Virginia, which has quietly spent \$4 million to \$5 million a year on hypersonics for more than a decade.

"We've made sustained and steady progress," said Lana Couch, NASA's manager of the hypersonics program. "But we have several years of work ahead before the decision makers can choose a system and decide to develop it. By 1995 we will have laid the broad technology base that will make it possible for this country to build an operational hypersonic aircraft."

The U.S. aerospaceplane concept differs markedly from the British design. The basic version would be powered by scramjets, fly just below the edge of space at speeds higher than Mach 15, and operate from traditional runways. A more advanced plane would add rocket power to give it the extra kick needed to go into orbit from its cruising altitude.

Scramjet technology is a major key to the U.S. effort. "We're not talking about ramjets burning methane to reach Mach 5 or 6," said the White House expert. "They don't meet the demands of the spaceplane regime, and there's no

Continued



way those planes are going to fly out of the atmosphere."

Scramjets will be fueled by hydrogen and will draw their oxygen from outside air. Research at Langley already shows that scramjets can outperform rockets by a factor of 10 at speeds above Mach 6. But much detailed development work remains to be done.

And now, for something completely different

In contrast, the British HOTOL is to be powered by air-breathing rockets fueled by liquid oxygen and hydrogen. Those engines are a breakthrough in rocket technology, since they would draw oxygen from the atmosphere during much of the climb toward either cruising altitude or orbit. That reduces the amount of propellant that must be carried on board and, according to information released by British Aerospace Corp., "permits the use of wings to optimize the initial flight trajectory after takeoff from a standard runway." Details on how the revolutionary rocket engine works, however, are a closely held British secret.

HOTOL also would use a simple trolley, which parts company with the craft at liftoff, for its takeoff role. Its design calls for a gliding shuttle-like landing on a lightweight undercarriage. It would be a relatively small spaceplane, with a payload of just seven tons—less than one-fourth the shuttle's capacity.

So far, the British government has not announced an operational date for HOTOL. It is called simply "a launch vehicle for the 21st century." Initial missions would be unmanned, intended to place satellites in orbit. But the British envision an airline-type passenger module that could be placed into its cargo bay for piloted trips from London to Sydney taking little more than an hour.

"We respect the British as researchers," the White House expert told me, "but there's a real question about whether they have the wherewithal to pull it off."

No such question exists, at least in the minds of its advocates, about the U.S. aerospaceplane. The development program is run jointly by the Air Force, Navy, and NASA, and is headquartered at Wright-Patterson Air Force Base, Ohio. It has strong military overtones, particularly in terms of the aerospaceplane's potential for servicing orbiting lasers as part of the president's Strategic Defense Initiative.

"It's a single national program," said SDI spokesman Brig. Gen. Robert R. Rankine. "The phase that begins in 1986 attacks the critical technologies—propulsion, structure and materials, and aerodynamics."

The latter is particularly crucial. Research already completed shows that an aerospaceplane's shape is a vital element in making scramjet engines operate efficiently. The plane's underbody must funnel air into the engine at exactly the right velocity and temperature. If the fuselage is designed properly, air heated to more than 4,000 degrees F by the plane's forward motion will be slowed slightly, then funneled into the engine. Air temperature alone will ignite the hydrogen fuel.

Much of the development yet to be done involves computational fluid dynamics—the analytical field that studies how fast-moving fluids such as air act under conditions of high temperature and pressure. Only the advent of supercomputers makes the complex and lengthy calculations needed to design an aerospaceplane realistically possible.

"It's a real challenge in terms of engine integration with the airframe," Rankine told me. "Supercomputers allow us to do complete calculations of the airflow for both internal and external aerodynamics. We can find solutions that

[Continued on page 116]

British Aerospace HOTOL would take off from a rolling trolley, use secret air-breathing engines to loft a seven-ton payload into orbit, and land much like the shuttle (left).

URANUS!

Ever since its discovery 205 years ago, Uranus has presented a bafflingly blank face to astronomers. Now, a stalwart space probe, Voyager 2, has sent back tantalizing photos of the ringed planet and its mysterious moons that reveal features and phenomena never before seen in the solar system.

By **JIM SCHEFTER**

The blue-green planet floated dead ahead in black space. Girdled by narrow boulder-filled rings and inky dark moons, its blank face glowed like a magician's crystal ball.

Out of the sun, a far-traveling spacecraft plunged toward the methane shroud of Uranus. Swiveling and shifting its dust-specked cameras to capture every possible image, the old and reliable explorer—a machine that could qualify as an authentic American hero—chattered a flood of reports to its home-world creators.

Through late January, scientists at the Jet Propulsion Laboratory, in Pasadena, Calif., watched and waited while Voyager 2 scanned the strange outer world and its curious collection of satellites. With each new bizarre revelation, the trash pile of discarded theories grew deeper, and the list of questions grew longer.

Among the most astonishing findings, gleaned from Voyager's magnetic and temperature detectors rather than its cameras: Uranus generates a steeply tilted magnetic field, somehow heats its strangely convective atmosphere, and hides an intensely hot and deep ocean beneath frigid blue-ice cloud tops.

The cameras saw only those smooth clouds, their methane ice crystals reflecting pale blue light. Searching for details in one of the remarkable photos, JPL astronomer Richard Terrile sighed wearily. "There are hints of things in the images," he said, "but not the obvious things we expected.

Uranus has done it to us again."

Indeed it had. For 205 years, since its discovery by William Herschel, Uranus has intrigued and mystified astronomers. At 1.8 billion miles from Earth, it is too far away to be easily studied by even the largest telescopes. Its smooth coat of azure methane clouds prevented observers from even discovering how fast it rotates. More confounding, some primordial cataclysm tipped Uranus on its side. Its south pole now points toward the sun.

After Voyager's incredible photos from Jupiter in 1979 and Saturn in 1981, scientists hoped for a blaze of visually bizarre discoveries at Uranus. They got half their wish: The photos told only part of the story.

The images showed the planet's five largest moons, with the moons' folded and ruptured surfaces becoming increasingly tumultuous as Voyager moved toward Uranus. In its swift passage through the Uranian system, the ship's cameras shifted from one moon to another to record sharp and detailed photos for playback to Earth.

They showed 10 newly discovered moons, sooty black and tiny. Two of the moons seem to shepherd the planet's largest ring, designated as epsilon.

They showed the rings themselves, 10 rather than nine, with the 10th ring perhaps only an arc of material instead of a complete circle. Defying predictions, the rings glowed more clearly in Voyager's photos when it approached Uranus than when it looked back after passing the planet.

Finally, there was Uranus, a smooth and textureless sphere in sharp con-

trast to the banded storms and Great Red Spot of Jupiter, or the colorful clouds of Saturn. Day after day, as Voyager approached, scientists waited for photos to show similar features on Uranus. They never appeared.

"Uranus is not giving up its secrets easily," said imaging team leader Dr. Brad Smith of the University of Arizona.

But when Voyager played back its images of Uranus's five largest moons, Smith and his team at last saw the alien terrains they had been expecting. Said planetary geologist Dr. Larry Soderblom of the U.S. Geological Survey, deputy leader of the imaging team, as he flashed the first clear close-ups of the moons on a large screen: "No one could have anticipated the exotic nature of what I'm going to show you."

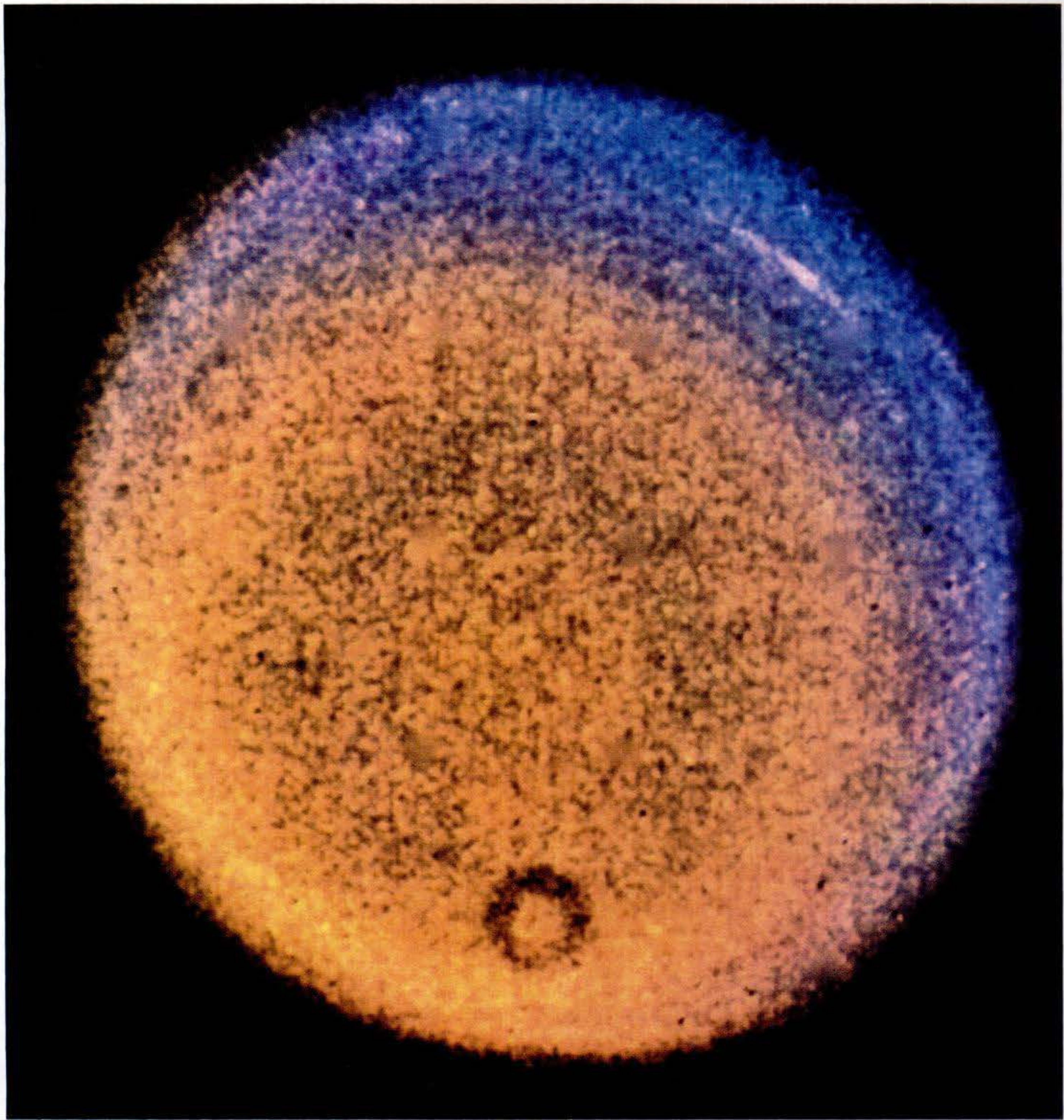
Lunar quirks

From distant Oberon to close-in Miranda, the moons of Uranus displayed surfaces of incredible variety. All were dark, absorbing more than three-fourths of the faint sunlight reaching them. Voyager brought out their surface details by taking time exposures, from 15 to 90 seconds per frame. With one startling exception, each moon closer to Uranus showed a more violent and active surface.

"What we're seeing is an increasing ferocity in the way these bodies have been shuffled in cataclysmic fashion," Soderblom said.

Oberon's icy surface is pocked with craters, one of them flooded with dark

Continued



material that erupted from beneath its floor. The material may be methane-rich water ice. Methane exposed to ultraviolet radiation turns black in 1,000 years or so. A 21,000-foot mountain, perhaps the central peak of another crater, peaks above Oberon's horizon.

At Titania, Voyager's cameras showed many craters and deep canyons ripping through the surface crust. The canyons, Soderblom said, indicate tectonic action from an active, dynamic interior.

The middle moon, Umbriel, broke the trend of increasing activity. Its sur-

face is a muted pattern of overlapping craters with little sign of other activity. Its only distinctive feature is one large crater, about 150 miles in diameter, that appears partially filled with light-colored ice. Umbriel is old and inactive, Soderblom guessed, somehow sandwiched between a series of extremely active younger moons.

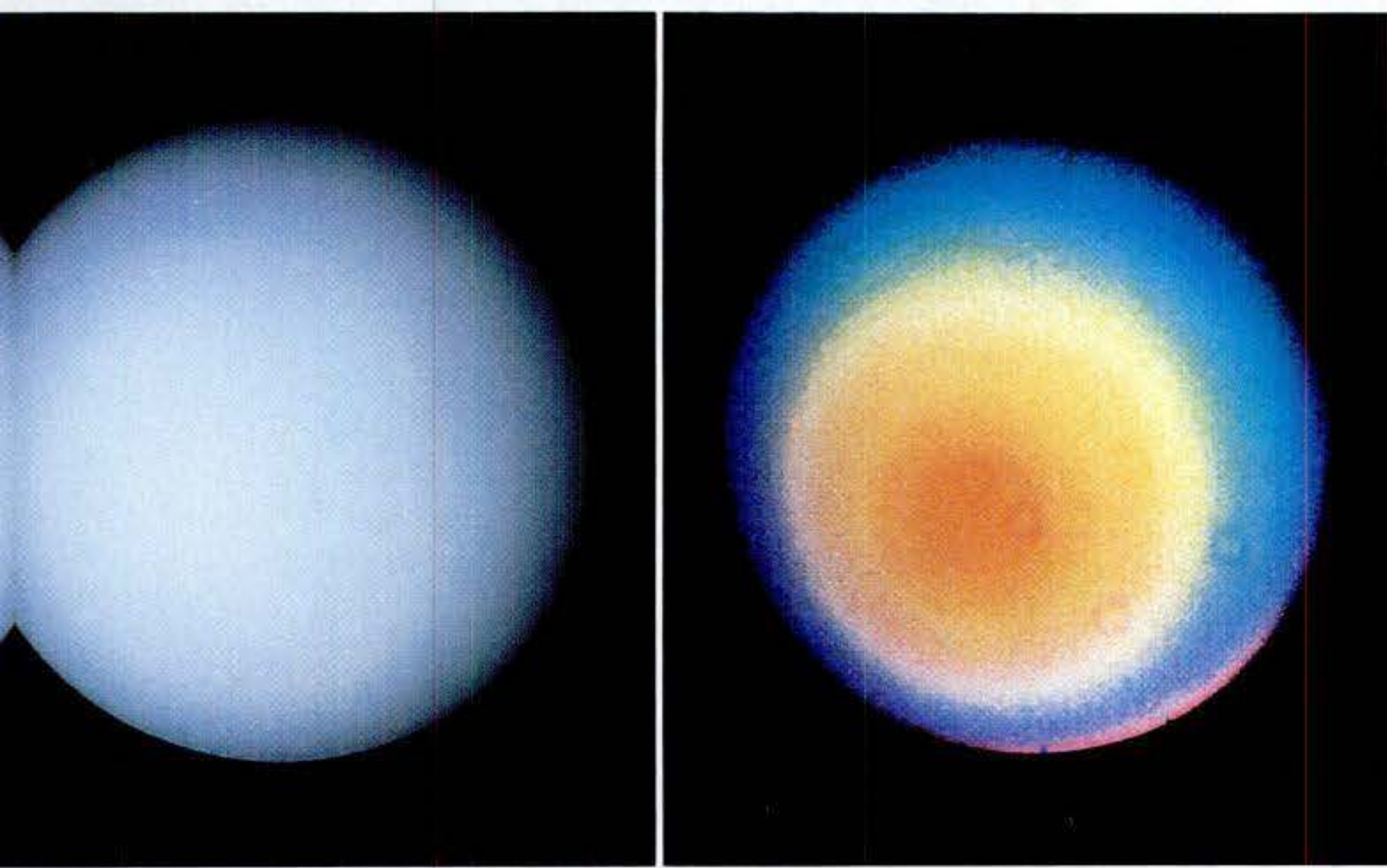
Next came Ariel. Obviously enthralled with its varied surface, Soderblom pointed to long valleys, some narrow, some wide. Fault systems were clearly visible, cutting deep incisions and jostling Ariel's crust with a complex network of tectonic overprints. In

one region, a trio of linear patterns appeared. "These are the kind of patterns you see from glaciers on Earth," Soderblom explained, implying that an icy mass flowed through the spot some time long ago.

Marvels of Miranda

But it was tiny Miranda, just 310 miles in diameter, that displayed the most curious and surrealistic surface. Seemingly made of patches cut and pasted from other moons and other worlds, it showed different and distinctive terrains.

[\[Continued on page 120\]](#)



A false-color photo of Uranus (opposite page) clearly shows a cloud—seen as a white streak near the limb of the planet. The exaggerated colors may reveal smog-like components in the Uranian atmosphere. The two photos of Uranus at left, one (left) in true color, the other in false, were made when Voyager was 5.7 million miles away. The methane atmosphere absorbs red light, yielding the blue-green hue of the true-color image. The false-color image shows a dark polar hood, possibly caused by a brownish haze that has become banded by atmospheric rotation. The bizarre surface of Miranda appears below in a photo made when Voyager was just 19,000 miles distant, and has a resolution of 2,000 ft. A long and complex geologic evolution of this moon is evidenced by the puzzling array of craters, grooves, and fractures, exhibiting a variety of reflectances, and thus different materials.



Chunnel for

Europe's biggest civil engineering project, twin rail tunnels beneath the English Channel, will penetrate an ideal medium—soft, watertight chalk. But engineers, wary of potential hazards along the route, are calling on the latest tunneling technologies.

By **JOHN FREE**

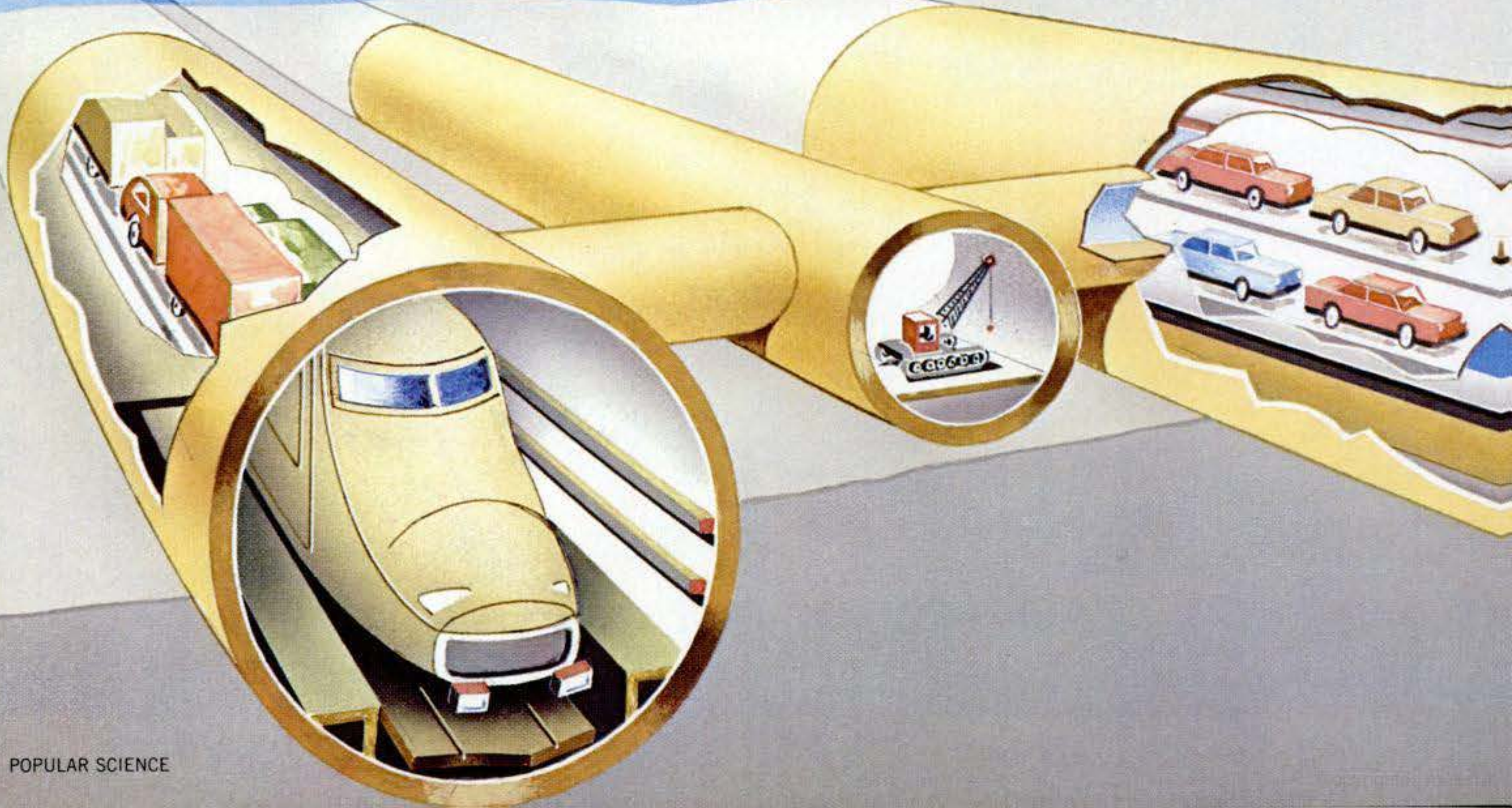
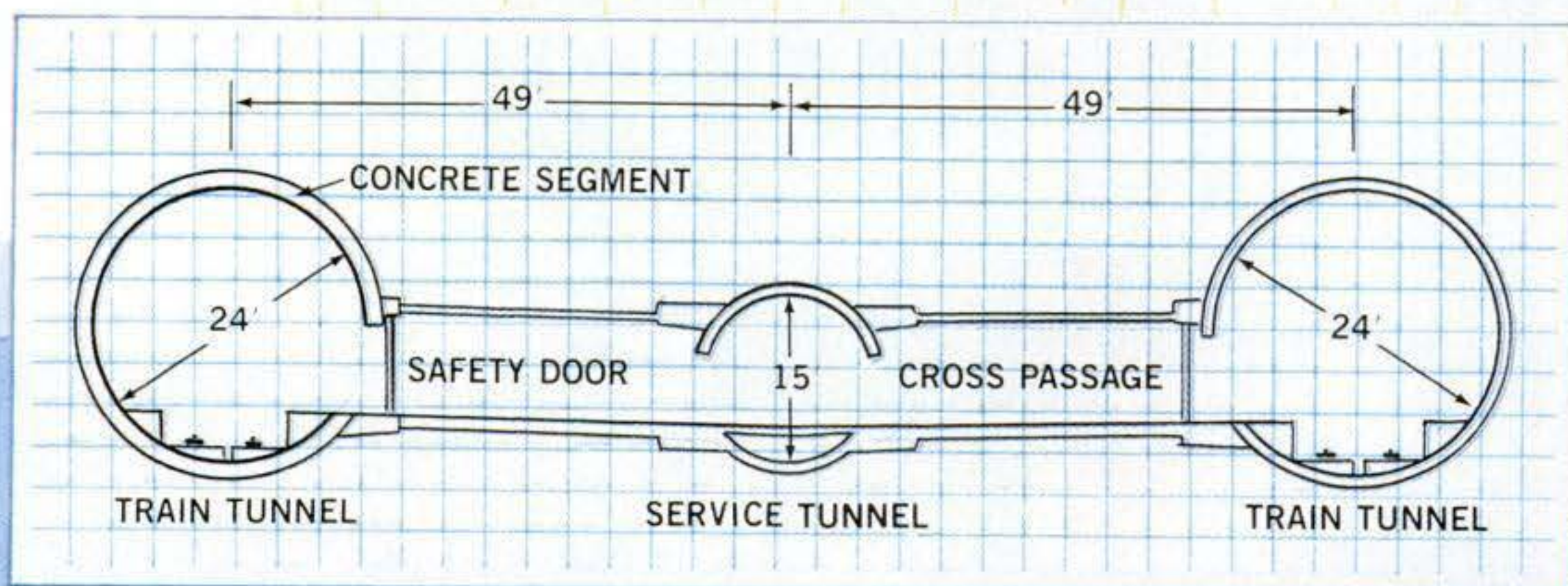
Drawings by *Walter Hortens*

Colorful British and French flags bedecked city hall in the French city of Lille early this year. Schoolchildren waved tiny flags, and bands played the *Marseillaise* and *God Save the Queen* before French President François Mitterrand called it “a grandiose vision of the future.” British Prime Minister Margaret Thatcher, although not fluent in French, dubbed it *passionnant*

—exciting. It should be exciting; it's been delayed more than 200 years.

“It” is something that was set in motion by an agreement, signed in Lille, between the French and British: the construction of the Chunnel—a tunnel under the English Channel—to link the countries.

The Chunnel project oozes superlatives. It will be the largest civil engineering project in the history of Western Europe. Thousands of workers will support some of the world's most advanced tunnel-boring technology to push



the channel

three parallel tunnels the 31 miles from Cheriton, in Kent, England, to Frethun, in northern France. Work is slated to begin next year. The first paying customers should zip between England and France in 1993. Following the announcement, I visited London to learn more about this frequently delayed project.

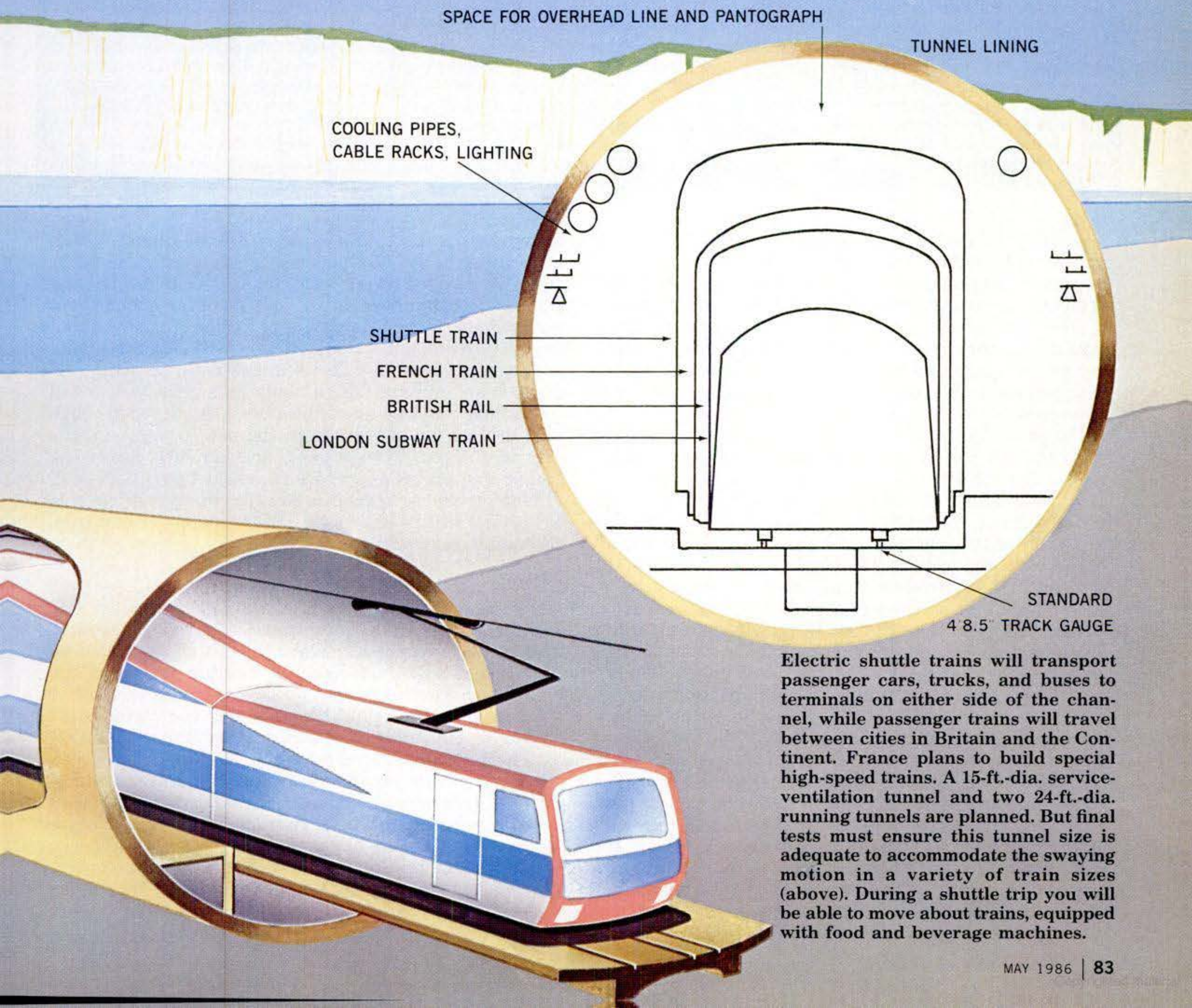
The most remarkable thing about the Chunnel is that the countries now seem serious about building it. Perhaps the earliest tunnel proposal came from French engineer Nicolas Desmaret in 1753. Napoleon resurrected the idea in 1802. In the 1870s, British and French companies began drilling shafts from opposite sides, then quit. The idea surfaced again in 1907, 1916, 1924, 1930, and the early 1960s. A *POPULAR SCIENCE* article in July 1960 outlined plans. That project, actually started in the 1970s, halted when the British pulled out, saying it would cost too much.

So why will it work this time? Says Bill Shakespeare, a publicist for the British group promoting the project: "We're convinced the political will to build it exists. The reality of the traffic buildup across the channel forces a solution of some kind on both governments."

The numbers bear him out. Surveys estimate that cross-channel traffic will double by the year 2000. That would far exceed the capacity of present cross-channel ferries, which are subject to delays from weather and labor conflicts. The Chunnel will initially handle 1,000 vehicles an hour. Its maximum capacity is four times that—enough to handle traffic well into the 21st century.

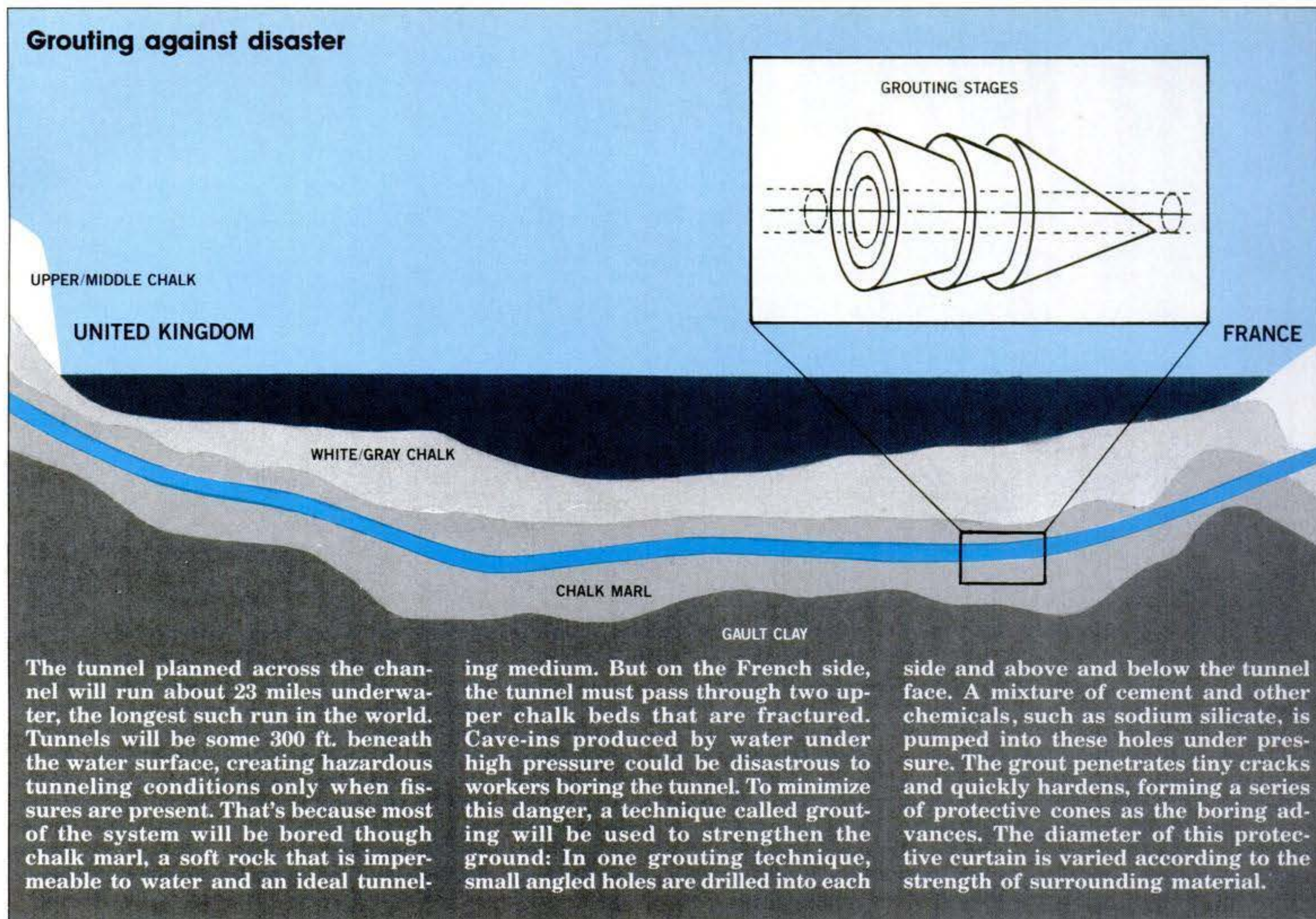
Other reasons to expect success: Technology is available to do the job, and planning is exhaustive at the Channel Tunnel Group and its French partner, France Manche,

Continued



Electric shuttle trains will transport passenger cars, trucks, and buses to terminals on either side of the channel, while passenger trains will travel between cities in Britain and the Continent. France plans to build special high-speed trains. A 15-ft.-dia. service-ventilation tunnel and two 24-ft.-dia. running tunnels are planned. But final tests must ensure this tunnel size is adequate to accommodate the swaying motion in a variety of train sizes (above). During a shuttle trip you will be able to move about trains, equipped with food and beverage machines.

Grouting against disaster



The tunnel planned across the channel will run about 23 miles underwater, the longest such run in the world. Tunnels will be some 300 ft. beneath the water surface, creating hazardous tunneling conditions only when fissures are present. That's because most of the system will be bored through chalk marl, a soft rock that is impermeable to water and an ideal tunnel-

ing medium. But on the French side, the tunnel must pass through two upper chalk beds that are fractured. Cave-ins produced by water under high pressure could be disastrous to workers boring the tunnel. To minimize this danger, a technique called grouting will be used to strengthen the ground: In one grouting technique, small angled holes are drilled into each

side and above and below the tunnel face. A mixture of cement and other chemicals, such as sodium silicate, is pumped into these holes under pressure. The grout penetrates tiny cracks and quickly hardens, forming a series of protective cones as the boring advances. The diameter of this protective curtain is varied according to the strength of surrounding material.

a privately funded consortium selected for the project. To uncover details about their scheme, I first visited Michael Gordon, managing director of the Channel Tunnel Group, at his temporary offices in a trim central-London house.

"The costs of our construction are fairly predictable," says the Cambridge-educated mechanical engineer, showing me drawings and summaries of proposals that fill a long bookshelf. "It's conventional tunneling through a medium that is well known and well researched."

The project calls for two 31-mile-long, 24-foot-diameter train tunnels with a 15-foot-diameter service tunnel between them. Every 1,125 feet, the three shafts will be connected with cross-links. "You can walk through to the service tunnel," says Gordon. "These cross-links are necessary for security in case you have a breakdown or fire."

The train tunnels are 31 miles long but will cross the channel at its narrowest point, 22 miles from shore to shore. They will be carved through a chalk layer about 130 feet below the channel floor. Double-deck shuttle trains for passenger cars and other shuttles for trucks and buses will cross the channel in 30 minutes—at up to 100 mph.

Although technology planned for the privately financed project is conventional and engineers know the geology, no one expects the job to be easy. Most of the work will be done by giant moles—tunnel-boring machines with circular cutting faces the size of the tunnel being bored. The giant cutter heads, driven by up to 2,400 horsepower, push dozens of carbon-steel discs against the tunnel face with up to 50,000 pounds of pressure. Fortunately, most of the path planned for the Chunnel project is through a chalk-clay material. "It's an ideal material," says Gordon. "It's easy to bore through and almost impervious to water."

Because the chalk-clay substance is almost waterproof,

the workers will not have to pressurize the tunnel. "What we're going to do," explains senior engineer Colin Kirkland, "is drive the fifteen-foot pilot, or service, tunnel several kilometers ahead of the other tubes. About every hundred fifty feet we'll stop and probe ahead another hundred feet to find out if there are any areas likely to cause problems." If faults are detected, holes will be bored into the rock and injected with a cementlike grout to seal and strengthen the area ahead (see box). "At the same time we'll drive a fan of holes from the pilot tunnel into the path of the other two tunnels and similarly study the ground and pretreat it where necessary," says Kirkland.

As the tunneling machines advance, the cylindrical hole left behind will be lined with either concrete or cast iron, depending on conditions.

Pressure shields

Drilling problems for the French are more complex. Unlike the British, they must tunnel through water-filled fractured layers of rock to reach the chalk-clay tunneling layer below. Says Jean Renault, director general of the French construction team: "We have a good idea of what we're going to meet and have planned our methods accordingly." The first part of this strategy is to use a different kind of tunnel-boring machine. The French have been negotiating with Japan's Kawasaki to obtain machines with full-face pressure shields: These develop a powerful localized pressure with a slurry or other materials to counteract water pressure at the drilling face.

How do you ensure that French and British workers starting 31 miles from each other will meet in the middle of the channel? Lasers will play a key role from start to

[Continued on page 114]

Push-pull windmill

The inventor of a vertical-axis wind turbine with three hinged airfoils that swing out to catch the wind says the new design produces electricity more efficiently than propeller-driven windmills. Part of the reason: a clever narrowing air-gap arrangement that creates a low-pressure zone behind each wing to help pull the rotor around.

By **ROBERT GANNON**
Painting by Adolph Brotman

Christian Herrmann, a round-faced German in a starched white shirt, waves a hair dryer toward what looks like a model of a segmented lighthouse in his sparsely furnished Chicago office. When he swings the dryer closer to the structure, metallic pinwheels within the tower begin to spin.

"It's a vertical wind farm," Herrmann says above the whir. "Instead of individual windmills scattered across the landscape, my rotors can be stacked on top of each other."

If the German engineer's calculations hold up, the Venturi Rotor wind turbine—as yet hardly off the drawing board—would offer several advantages: long life, little noise and maintenance, and low-cost production of electricity. It remains to be seen, though, whether falling oil prices will affect the economic feasibility of the design.

Herrmann, a 41-year-old former West Berlin University professor and ex-head of a Berlin-based research and development firm, conceived the idea for the rotor during the oil shortage several years ago. "I asked myself: Why couldn't we use windmills in cities? First, we could flip them over ninety degrees, and then we could build them *into* buildings shaped to funnel air toward a high stack of generators."

The now-patented concept that emerged is a vertical-axis turbine with only three main components (see illustration, next page): a rounded triangular central core—a barrier redirecting the wind to its perimeter—with three sets of airfoils swinging in the breeze on a trio of supports.

When the wind blows, the wings swing out to catch it. Meanwhile, special gaps between the airfoils and the core create low-pressure regions behind the wings, which help suck the rotor around.

Continued



Prototype version of the Venturi Rotor, a novel swing-wing wind turbine, in Oronogo, Mo. After damage by vandals, it was dismantled. Christian Herrmann, the inventor, uses a blow dryer to demonstrate operation of a model rotor.

PHOTO BY THE AUTHOR



The venturi effect

Hold two sheets of paper a finger thickness apart and blow between them: They tend to move toward each other. The reason, as concluded by Italian physicist G. B. Venturi some 200 years ago, is that the pressure of a fluid (in this case, air) drops as its velocity increases. The paper sheets converge because the air pressure between them is less than that of the surrounding air.

Several years ago, Herrmann and his wife moved to Joplin, Mo., where he built a one-section prototype. The windmill sat on a gently sloping hill in Oronogo, like a three-story winged silo of honeycombed foam-filled aircraft aluminum. At the structure's bottom sat a Herrmann-designed electric generator—an AC induction asynchronous device that he describes as “a linear generator turned into a circle and smashed down into a pancake.”

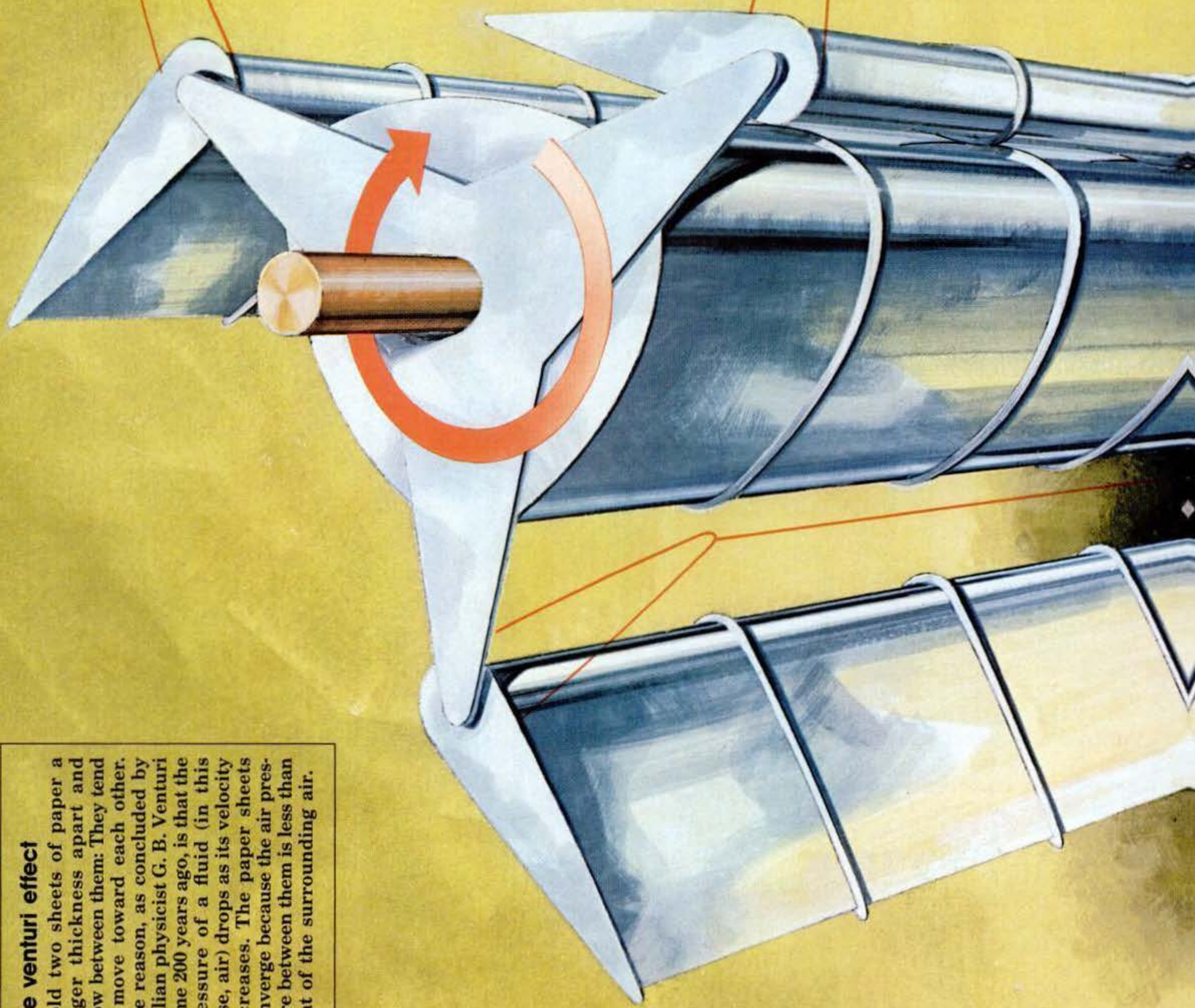
During the six months in which the assembly braved the Missouri winds, Herrmann confirmed that:

- The equipment began to revolve in a 1.3-mph wind, a breeze you can hardly feel. The generator kicked in at 6 mph, producing 0.1 kW. At 15 mph, it generated 3 kW; at 25 mph, 13.8 kW; and at 65 mph, 150 kW.
- At very slow speeds, the rotor revolved on oversized, greaseless bearings; but as it picked up speed, two magnetic fields—one induced by current from the generator and another produced by eddy currents formed within the rotor—repelled each other, causing the assembly to levitate and ride friction-free. “With this multipole, direct-drive machine,” Herrmann notes, “I need no reduction gear—and that means no lubrication, wear, or noise problems usually associated with gears.”

- Noise during operation was low, which was welcome news because windmills are not noted for being quiet. The main reason for the low noise levels is the relatively slow revolution rate. Even the sound of the blades opening and closing was surprisingly muffled.

- Safety, also a niggling worry, seemed to be no problem: The machine's rotation rate was so low that even in the heaviest wind there was little danger of blades flinging off.

Longevity—probably the single most important attribute of a wind generator—couldn't be easily mea-

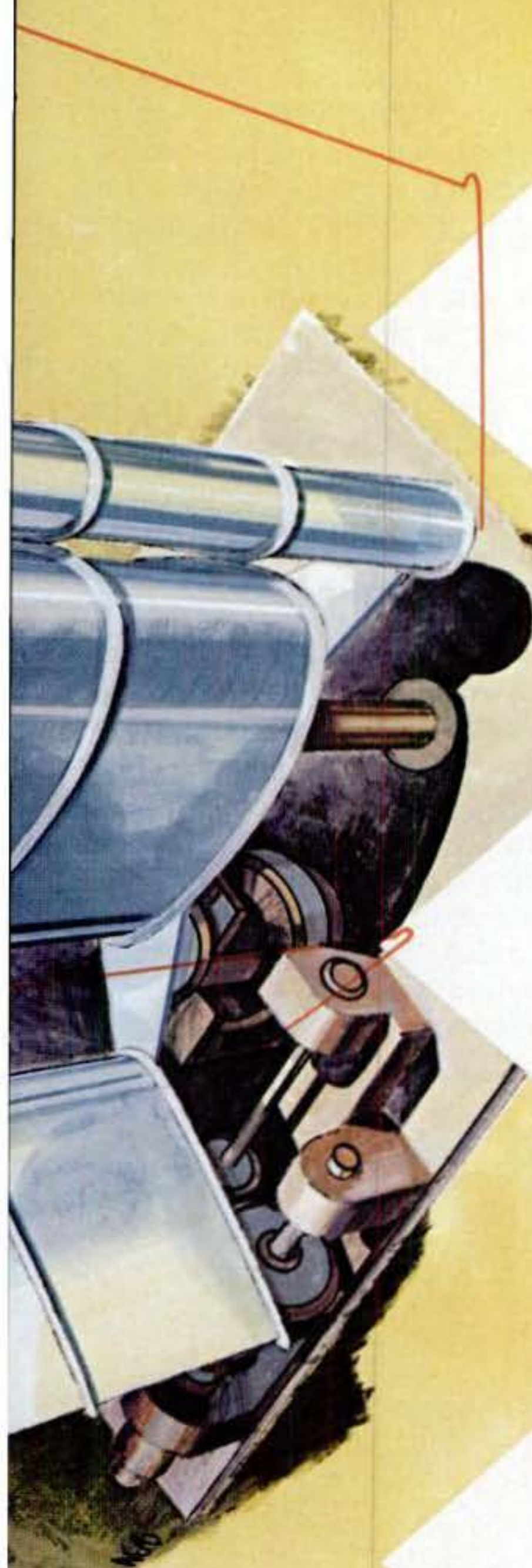


sured, but Herrmann feels that the unit could last 30 years. Even bad weather, the long-term bugaboo of most wind generators, was no problem in Missouri. During two severe ice storms, the wind-streaming prevented ice formation. Ice did accumulate in conditions of freezing rain and still air, but it sloughed off as soon as the structure began to turn.

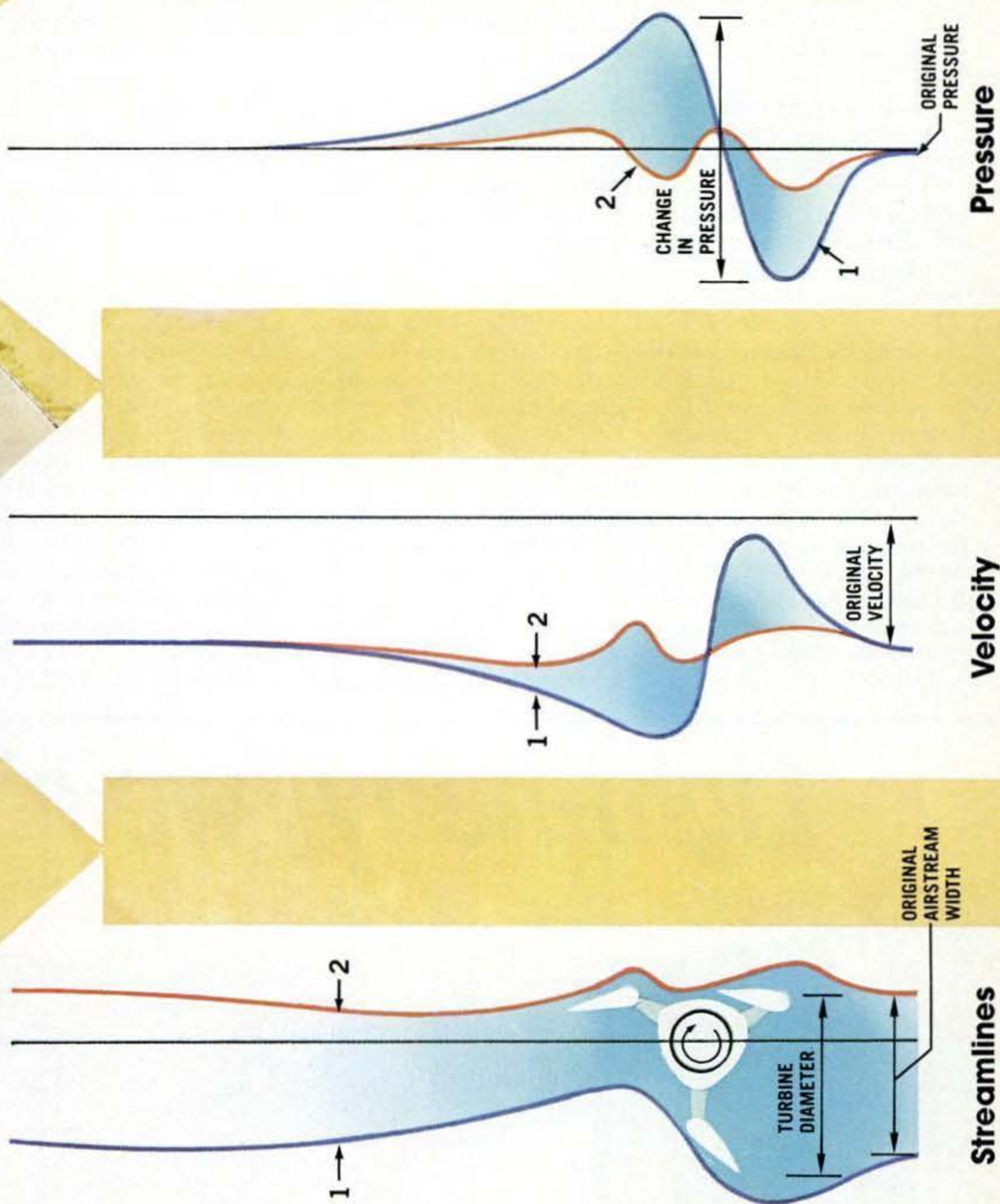
And then there was the night a tornado roared across the knoll. The result: ripped-down trees and a torn-off control-building roof. But Herrmann's Venturi Rotor, aside from a few minor dents, remained unaffected. Steel cables kept the assembly from toppling, and an automatic governor checked the speed.

"By the time wind speed reaches eighty miles per hour or so," Herrmann explains, "centrifugal forces have flung the wings open, and they're running open, *against* the wind, slowing the machine down." What the wind couldn't destroy, however, mysterious strangers did. Because of pending lawsuits, Herrmann won't talk much about it, but somebody—driven, he

[Continued on page 118]



WIND



When a breeze strikes the windmill (left), air is forced between the central core and the air-pressure-loaded swing wings. The latter flap out like spinnakers on the downwind side to act as airstream collectors, then fold in on the upwind part of the cycle. As the wings swing outward, the gaps between the airfoils and the central core narrow, and air rushing through is squeezed and speeded up. This high-velocity airstream creates low-pressure areas in the gaps and behind the airfoils in accordance with the venturi effect (see box above left). These low-pressure zones help pull the wing around. The airstream's position, speed, and pressure at any point are shown at left in graph form. The electric generator at the base is not shown.

Pocket K-car

Once again, Chrysler has reached into its parts bin and pulled out a new car line. PS drives the Shadow and Sundance to see how well the pieces work together.

By DAN McCOSH

Driving through the rocky canyons north of Phoenix can't help but feel familiar, even if you're testing a brand-new car. After all, the Arizona desert has been the setting for hundreds of westerns. But driving the new Dodge Shadow there, I found the feeling of familiarity almost overwhelming.

That's not surprising when you consider the Shadow and its subcompact twin, the Plymouth Sundance. After all, Chrysler is a master of Rubik's Cube engineering—taking the basic pieces of one automobile and rearranging them into everything from sporty coupes to mini-vans.

Now comes the latest twist: The Shadow and Sundance are shortened versions of last year's Lancer and LeBaron GTS sport sedans. Along with the smaller size comes a lower base price, about \$7,300 compared with \$9,800 for Lancer. Otherwise, the family resemblance is remarkable.

Shadow and Sundance share engines, transmissions, steering, and suspension with the Lancer and LeBaron GTS. All these pieces, of course, trace their heritage back to the original K-cars, the Aries and Reliant, introduced in the fall of 1980. Such commonality is, well, common. It's the underlying principle that allows car makers to reduce cost by standardizing basic under-hood components while still offering a variety of body styles.

Base engine for the Shadow/Sundance is the plain-vanilla

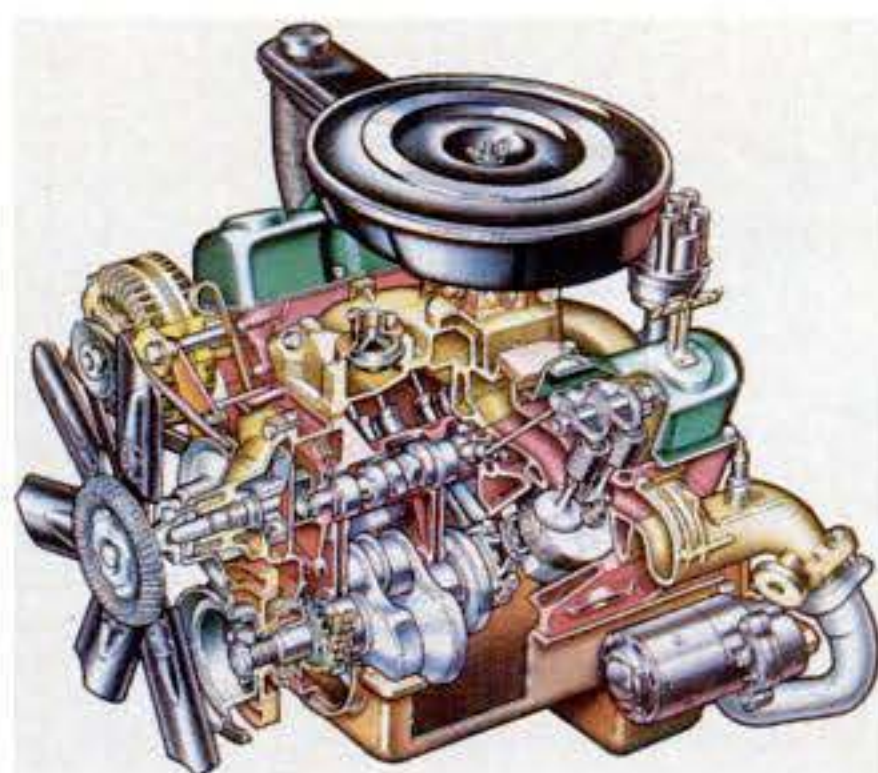
2.2-liter four. With single-point fuel injection, it produces 97 horsepower. The optional turbocharger boosts power to 146 horsepower. For transmissions, customers can choose a five-speed manual or three-speed automatic. Suspension is via MacPherson struts up front, with a twisting-beam axle holding up the rear.

Even on the basic car, the chassis is tuned on the stiff side, so much so that the handling upgrade consists exclusively of larger wheels and tires. On twisting roads, the Shadow and Sundance exhibit the same predictable handling common to most front-drive Chryslers. They are particularly impressive in power-on, power-off cornering and in downhill braking, two areas where some front-drive suspensions become treacherous.

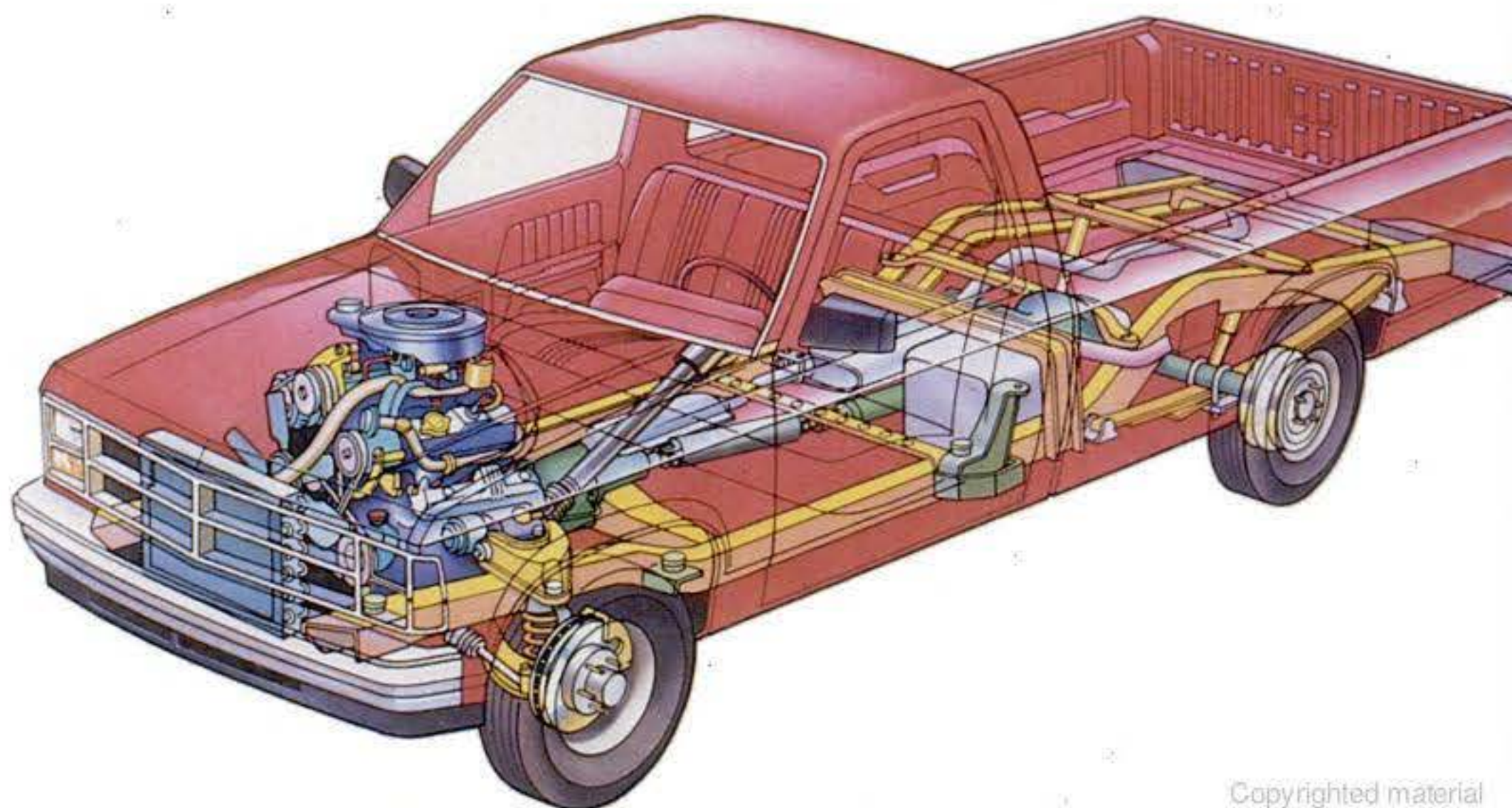
Acceleration, however, is less impressive. Just one passenger can erase the car's 192-pound weight advantage over the 2,646-pound Lancer. And with three passengers aboard, the test car with the 2.2-liter engine and three-speed automatic struggled to a 14.7-second zero-to-60-mph time. A turbo-equipped car clocked a 10.5-second time under similar conditions. The base engine is marginal; the turbo package is slightly better than adequate. Chrysler seems to be thinking along similar lines: A Shelby-prepared Shadow will likely find its way into production soon.

Along with the familiar engines, the manual transmission used in the Shadow/Sundance has the same notchy shifting found on other Chryslers. It was particularly ir-

Light-heavyweight hauler



The Dakota is Dodge's new mid-size pickup. Its optional 3.9-liter engine was derived from Chrysler's 5.2-liter V8.



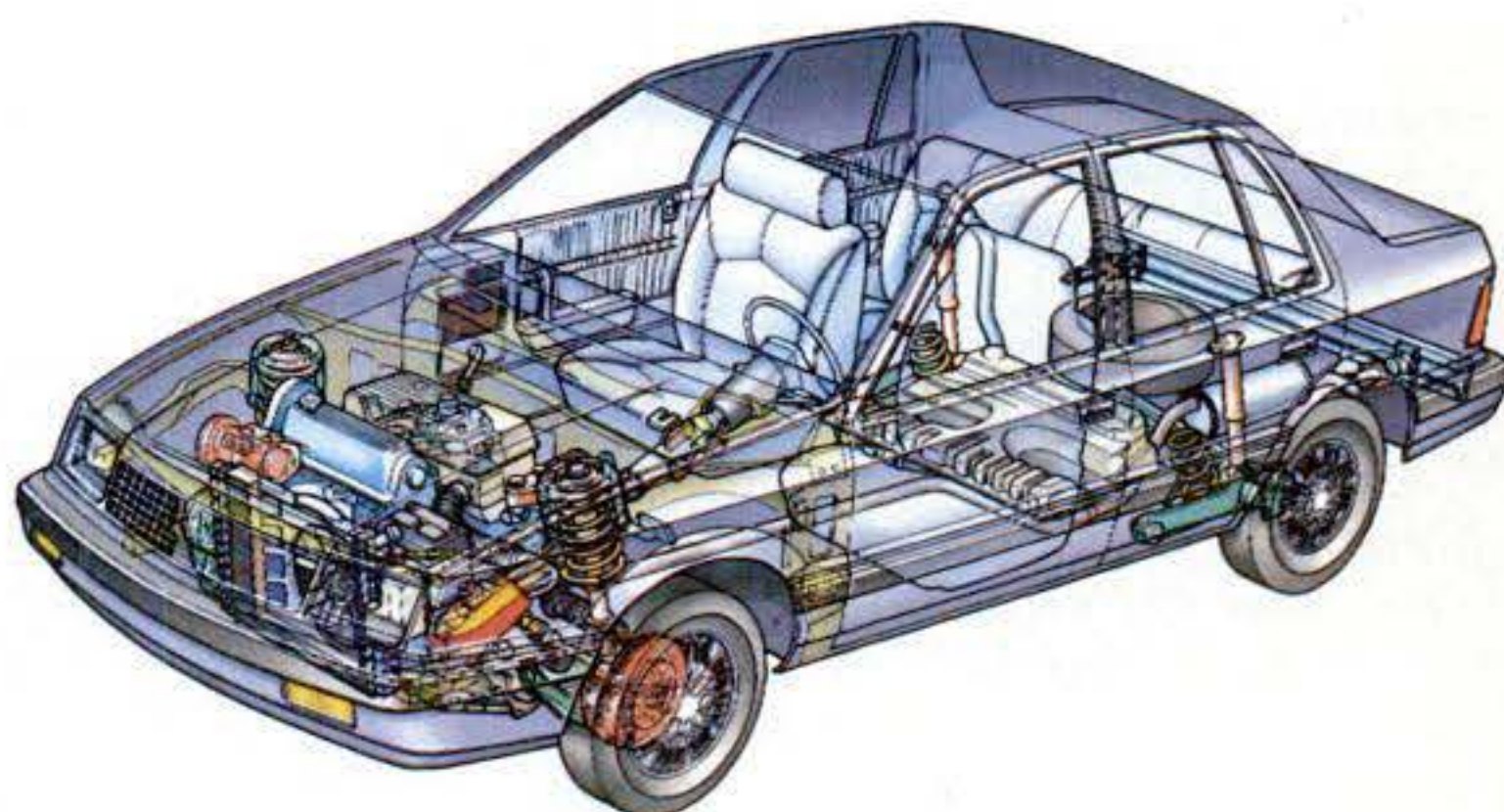


ritating when engaging first gear after a stop. "It's something we keep working on, but we've still got a way to go," says Floyd E. Allen, chief engineer for power trains.

Until shortly before its introduction, the Shadow and Sundance were supposed to replace the aging Omni/Horizon as a basic economy car. But Chrysler closed a deal to buy subcompacts built in the U.S. by Mitsubishi and decided to extend the life of the Omni/Horizon indefinitely. Company insiders say this killed plans for a 1.8-liter economy engine for the Shadow/Sundance and resulted in a higher sticker price than was originally planned.

In their current evolution, the Dodge Shadow and Plymouth Sundance are a straightforward design aimed at a price niche teaming with domestic and foreign competition. They're a bit like the old sheriff riding into one of those Arizona canyons. We'll have to wait and see whether his faithful horse and trusty six-gun will be a match for what's lurking there.

PS



Shadow/Sundance exterior bears a strong resemblance to the larger Lancer and LeBaron GTS. Under the skin, the car shares the 2.2-liter engine, transmission, and suspension components used on other front-drive Chryslers.

It's not too big, and it's not too small. The ride's not too hard, but it's not too soft. And as for hot and cold, the heater and air conditioner worked just right during my test drive through Arizona mountains and deserts. Yes, I think Goldilocks might like the new Dodge Dakota.

The Dakota is a mid-size pickup that attempts to blend the best of full-size and compact trucks. Dodge also hopes it will straddle the car and truck markets. With its relatively smooth ride and carlike interior, it will court the buyer looking for daily transportation. But Chrysler also thinks it will provide enough power and load-carrying capacity to appeal to commercial users.

During my drive through Arizona's scenic Oak Creek Canyon, the Dakota handled the mountain switchbacks

with only moderate body roll and a touch of understeer. Later, motoring down an arrow-straight desert road, I was surprised by the low noise level—the result, in part, of the flush-mounted windshield, rounded A-pillars, recessed rain gutters, and six rubber mounts between the cab and body.

For utility users, the Dakota offers a choice of 6.5- or eight-foot beds. The larger size will take a four-by-eight-foot sheet of plywood across the wheel wells. Chrysler will offer three payload levels: 1,250, 1,800, and 2,550 pounds. Properly equipped, the Dakota can tow 5,500 pounds.

The standard engine for the rear-drive Dakota is a 2.2-liter four that generates 94 horsepower. Based on the familiar 2.2 used in Chrysler passenger cars, the engine is fitted with a

fast-burn cylinder head and computer-controlled two-barrel carburetor.

Optional on the Dakota is a new 3.9-liter V6. It also uses fast-burn cylinder heads and a computer-controlled carburetor. The V6 generates 125 horsepower, and it delivers a stump-pulling 195 foot-pounds of peak torque at a remarkably low 2,000 rpm.

A new five-speed manual transmission, which was designed specifically for truck use, is standard on the Dakota. A three-speed automatic is available on V6-equipped models.

The Dakota enters a market crowded with pickups of all sizes. But Chrysler seems unfazed. Says Pat Keegan, general manager for truck operations, "It's larger than import or domestic compact models, and smaller than full-size pickups." Or, as Goldilocks might say, just right.—Steven Ashley

SUPERSHOT

The Canon T90 has 14 buttons, three motors, three switches, three levers, and a rotary dial. Even if you never take another photograph, you might want to own this extraordinarily sophisticated camera—just for the tech of it.

By ARTHUR FISHER

It is not absolutely necessary to take pictures with a camera. You could, let us say, just experiment with its myriad controls, savor its craftsmanship, ogle its elegant lines. After all, there are collectors who purchase a rare astrolabe and never take a sight on the sun. And there are scads of people so enamored of precision automotive machinery that they will pay a small fortune for a car capable of 150 mph even though they will never see an autobahn.

Likewise, there are those who may lust after Canon's new \$600 (body only) T90 simply because it's there.

First, the camera is undeniably handsome. Its sculptured curves are sleek, sinuous, sensual. In fact, Canon's brochure for the T90 is lavishly illustrated with images of the camera body in a photographic style usually reserved for erotic portraits.

Moreover, the T90 exemplifies the current trend to ergonomic design. The now familiar right-side protuberance is coated with a non-slip material that makes it easy to heft the rather heavy (1 lb., 12 oz.) body. And the shutter release button sits on a curved and sloping surface forward of the camera's top—a very comfortable position.

But the most striking aspect of the T90 is this: Although it lacks autofocus, which Canon deems inappropriate for the serious amateur or pro, it is arguably the most technologically advanced (and complex) 35-mm SLR camera ever made.

Buttons, motors, and modes

Simply put, the T90 is *loaded*. There are controls, displays, features, options galore. Let me count the ways: At last reckoning, this camera has 14 buttons, three switches, three levers, and an electronic rotary dial. It has three separate displays, in a patriotic assortment of colors: a red LED at the bottom of the viewfinder, a blue-back-

ground LCD along the side of the viewfinder, and a large white LCD at the top of the camera.

The T90 also has three separate coreless computerized motors. One is for high-speed film rewind. The second operates the AE (automatic exposure) mechanism, the mirror, and the shutter; the speed range is 30 seconds to $\frac{1}{4,000}$ second, with flash synch at $\frac{1}{250}$ second. The third advances the film and provides a built-in motor drive with a choice of two shooting speeds—4.5 or 2 frames per second.

You are also offered a choice from a staggering 13 different exposure modes. Two of them are conventional aperture-priority and shutter-priority AE modes, but with a wrinkle: an optional safety shift feature that automatically overrides the preselected shutter speed or aperture if lighting conditions require. Furthermore, you can choose from among seven different program AE modes, depending on how you want to bias the program—whether you are more interested in stopping the action or in great depth of field. Then there are four less-automatic modes, including a manual one.

Metering modes? Take your pick of three: center-weighted averaging; partial, which covers 13 percent of the frame; and spot, which meters 2.7 percent of the frame. In the last mode, you can take as many as eight spot readings of a single view. The camera will average them for correct exposure.

There are even two separate exposure-compensation systems: One works in conjunction with spot metering and varies exposure by half stops; the other compensates by one-third stops.

What with all these modes, options, and systems, the number of different permutations available at the photographer's fingertips adds up to... but the mind falters.

And there's the rub. To master the intricacies of this camera, to take full advantage of the wealth of choices it provides, requires real dedication.

Although the learning process is not quite at the level of subduing a word-processing program, it can come close.

Read before you shoot

As evidence, take the instruction booklet. It is excellent, but it runs 127 pages. And more than most, these instructions should be read *before* attempting to use the camera. Two sobering episodes in quick succession taught me not to ignore this advice.

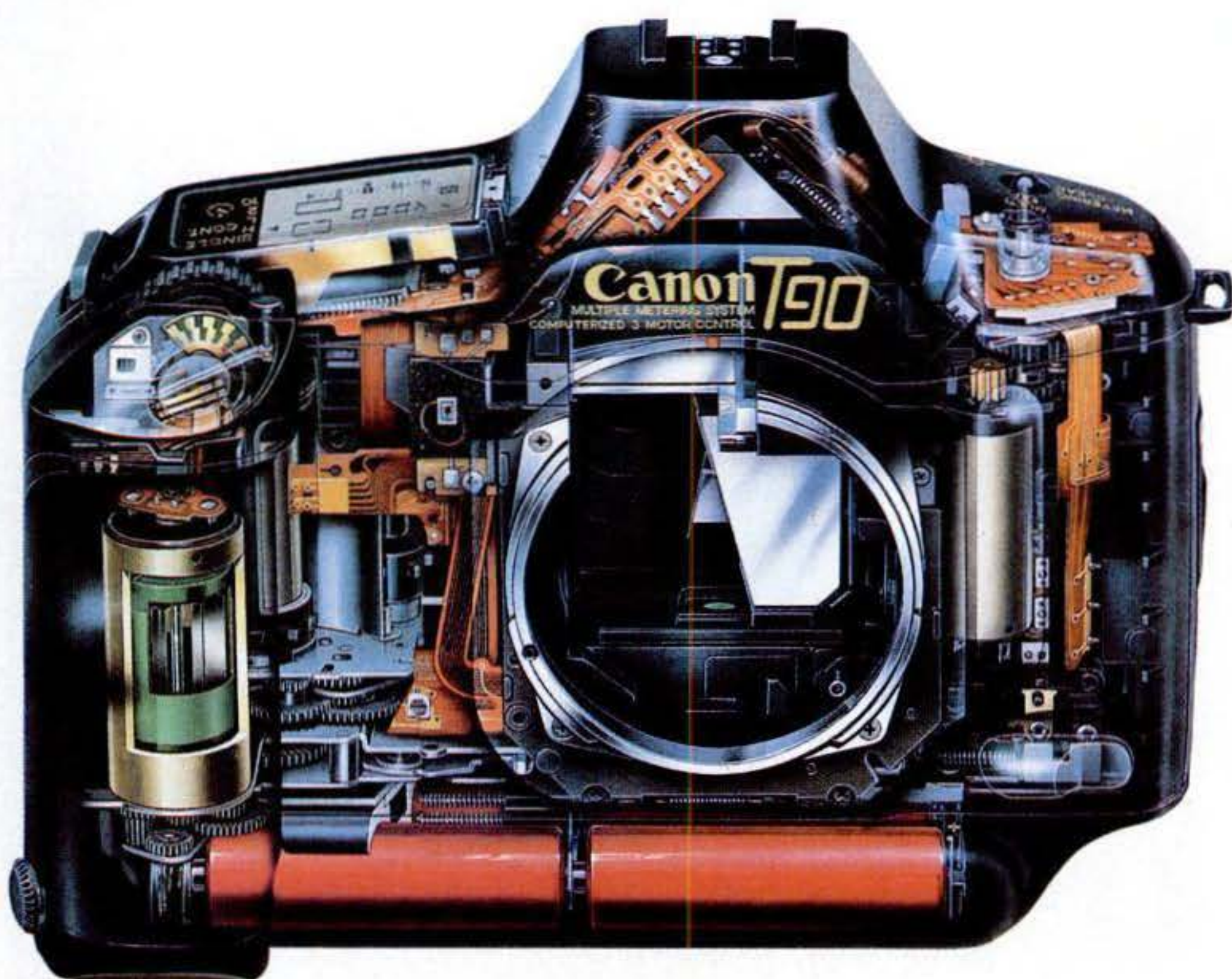
First, I encountered a totally dark viewfinder after switching the camera on. (No, I had not left the lens cap in place.) This is often the sign of a mirror malfunction or something equally grim. But I learned, after a frustrating 15 minutes, that I had inadvertently nudged a little lever that closed a shutter over the viewfinder window. This is a useful device—it keeps light out of the system when taking remote or self-timed photos—but I was simply unaware of it.

Second, while exploring the hide-away controls inside the hatch that opens on the right side of the camera (you can see it in the photo on the opposite page), I bravely pushed a tiny black button whose purpose I was ignorant of. Presto! The rewind motor zipped back into the cassette a 36-exposure roll of film on which only three shots had been exposed. I had pressed the manual rewind button.

Of course, you could avoid a great deal of effort by simply setting the camera to one of its pre-programmed, AE modes and forgetting the rest. But what would be the point? Unless you really are the technology-for-its-own-sake kind of collector, you will want to use the camera to the utmost of its capabilities.

And that raises the next question: Do you really need all the flexibility this camera gives? Or, as one jaded photography editor put it at Canon's press introduction, will all this stuff help you take better pictures?

The answers, of course, are up to you. PS



Three views of the Canon T90 reveal its glossy good looks and extreme complexity. The cutaway (left) shows the location of the three small motors and four-AA-battery pack along the bottom. The main LCD display at the top of the camera (above) gives exposure- and metering-mode data—even battery status. Inside the hatch at right are less often used controls, including a viewfinder display selector and timer.



Word machines

—a new touch to your typing

Need more than a typewriter? Don't want a computer? Try something in between: Low-cost home word processors provide simple and powerful processing.

By **WILLIAM J. HAWKINS**
 Photos by Greg Sharko

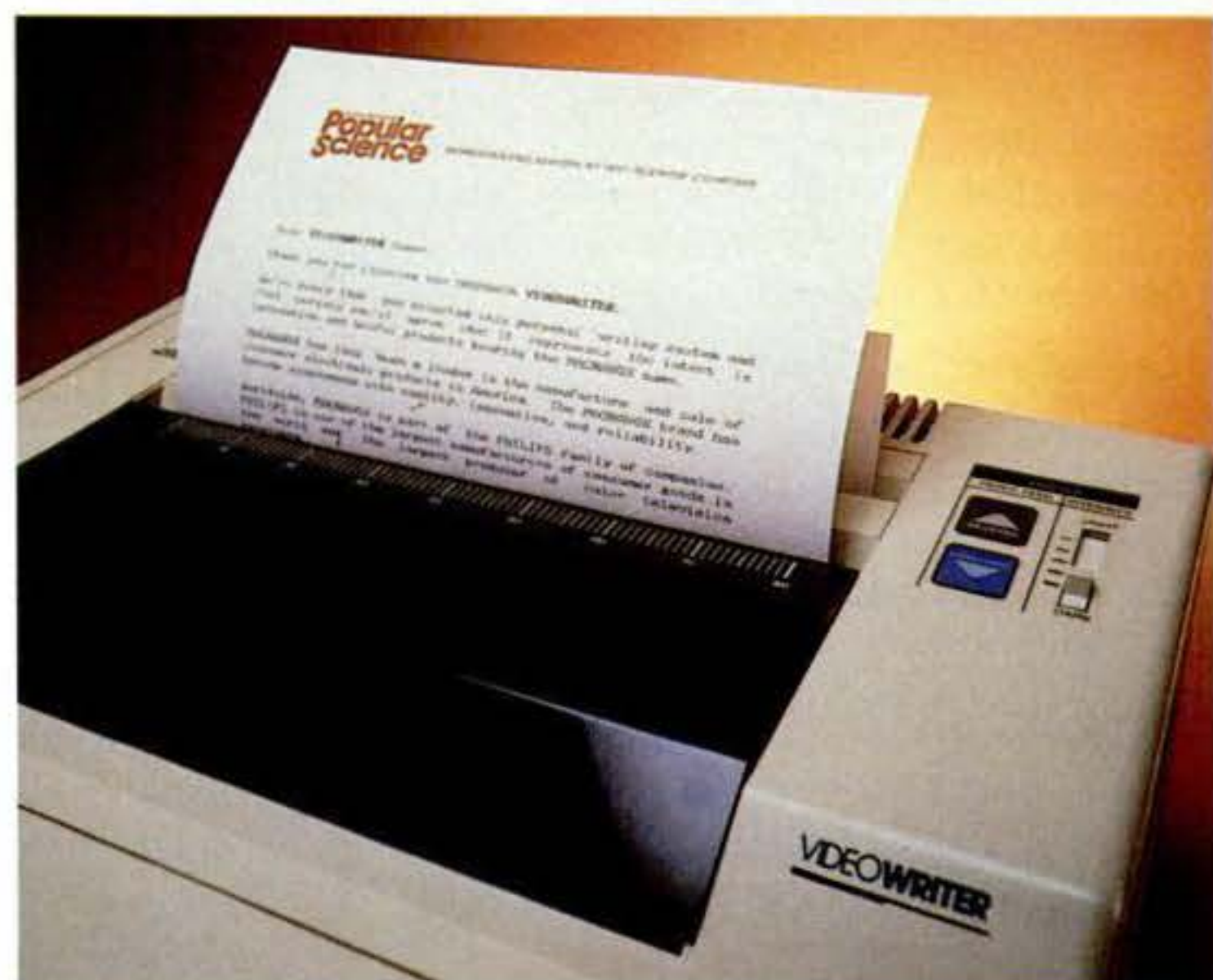
When my old typewriter finally gave out, I decided I needed something a bit better for processing words," says Steve Frimmer, a New York-based freelance writer. "I wanted to see more text than just the one- or two-line displays shown on the new electronic typewriters. But I didn't want the complexity or cost of a home computer." The solution to Frimmer's dilemma: a word machine.

For Frimmer—and millions of people like him who simply want a quick, efficient way to put words on paper—Smith Corona and Magnavox have created word processors for the home. They act like computers pre-programmed with word-processing software. But they're designed to be as

Continued



Smith Corona PWP starts by showing its available memory—roughly 64K, equivalent to about 32 pages of text—and opening menu (below). Selections are made on the typewriter keyboard. Text screen (right) displays the top rule line of margins, tab stops, and column position. Up to 24 lines can be shown at once. Text is edited using a separate key pad and saved on a cassette called a microwafer (see lead photo). Its base price is \$500; the electronic daisy-wheel typewriter adds \$300 to \$500, depending on the model. Print speed of all models: about 12 characters a second.



Magnavox Videowriter (\$800) uses three-quarters of its 3.25-by-8-in. screen to display 18 lines of 80-column-wide text. Usually the right quarter of the screen displays the cursor's present location in the text. But for special operations or setting page and printing formats (right), it displays help messages. The built-in printer (above right) accepts paper and envelopes up to 9 in. wide. Print speed varies from 25 to 50 characters per second, depending on character size and draft or letter-quality mode selection. Up to 70 pages of text can be stored on its 3.5-in. microdisk.

simple to use as a typewriter, and at about \$800, they are priced between the \$400 intelligent typewriter and the typical \$1,500 computer system.

"They're not typewriters," explained Louis Arpino, president of Philips Home Interactive Systems, parent company of Magnavox, "and they're not computers. These devices are a totally new type of product."

Each uses a CRT screen to display 80 columns of text; allows full-screen editing such as inserting, moving, or deleting words or entire sections; saves your work on disk or cassette; and produces letter-quality printed documents. But they differ sharply in appearance: Magnavox's Videowriter is an all-in-one unit with detachable keyboard. Smith Corona's PWP (Personal Word Processor) is a separate screen and electronics box, and is designed as an add-on for many of the company's electronic typewriters. The typewriter becomes the keyboard and printer for the word processor.

How well do they work? Are they as easy to use as a typewriter without sacrificing the features of a full-size computer? And how do the two machines compare? After trying both, here's what I learned.

Magnavox Videowriter

"To prove how easy these are to use," announced Philips' Arpino at the Videowriter's first New York showing, "I ask you to try one yourself." He waved his hand toward a stage filled with Videowriters. In a moment, the people attending the showing were seated in front of the glowing amber screens.

Easy to use? Without the aid of an instruction manual, everybody began typing and editing a document. It all seemed so easy, I even got a bit ahead of myself.

"Having a problem?" a demonstrator asked upon seeing my frustration in trying to load a piece of paper into the machine's top-side printer. Two buttons—one to advance the paper forward and a second to move the paper backward—had no effect when pressed. The paper wouldn't budge.

"You haven't told Videowriter you'd like to print something," she said with a smile. "Remember, this is a very user-friendly machine." I later learned, after using the machine at home, that user friendly means following the built-in steps for each operation.

Most operations are done by pressing a dedicated key on the keyboard. For example, type a line and press the "center" key, and your words instantly jump to the center of the screen. But on more complicated operations, you get help.

For instance, to move a block of text

from one place to another, press the "move" button. When you do, the right quarter of the screen displays instructions on how to do it.

The instructions tell you to move the cursor to the beginning and end of the text you want to move, and mark each point by pressing a "do" button. (The block of text becomes highlighted on the screen.) Next, you move the cursor to the new location for the text and press "do" once again. Result: In a couple of seconds the block moves, and the edited text is automatically saved on disk. The on-screen messages make it simple.

Any problems? Just one. There is also an "undo" button. When you press it, your last command is canceled—sometimes. Because major operations such as shifting or deleting text are saved on disk, they become permanent. If you've just accidentally erased your finest piece of creative work, you're out of luck: Pressing "undo" will only result in the message UNDO IS UNAVAILABLE.

**“Easy to use?
Without the aid of an
instruction manual,
everybody began
typing and editing a
document”**

Videowriter uses a dot-matrix thermal-transfer printer. When you press the "print" key, the screen displays printing options such as paper size, line spacing, and automatic page numbering. You can change them or accept the default settings. Then you are told to insert the paper, use the top "forward/reverse" controls to adjust it if necessary (*now* they work), and press "do" once again to start printing.

Print quality? Excellent. And because it is a dot-matrix printer, it can create wide, bold, superscript, and subscript characters, as well as the normal pica typeface.

Despite Videowriter's simplicity, I found it has built-in features only available on full-size word-processing systems. For example, a "split" button on the keyboard divides the screen in half. The top half contains your present work, the bottom displays the contents of another disk file. You could use the split function to move information from one file into another, refer to a file of notes, or create form letters. It's a handy feature.

There is also a "spell" button. Posi-

tion the cursor over a word in your text, and press this button. In about 10 seconds the computer checks the word against a 50,000-word dictionary stored on the disk. If the word is correct, the help screen tells you all is well and to continue your work. But if the word is not found, the screen shows you 10 close matches. Choose one of the matches, and it instantly replaces the misspelled word on the screen. If the word on the screen is correct and not in the dictionary (such as a person's name), you can add it to your own 1,000-word customized dictionary for future use.

Smith Corona PWP

"PWP is a natural extension of the typewriter for word processing," says Smith Corona's vice president of marketing Fred Feuerhake. The PWP is really a typewriter with an attached 12-inch video screen, electronics package with tape-cassette drive, and key pad.

The key pad contains the four usual cursor-control buttons plus a fifth "cursor advance" for instantly skipping to the end of a line or to the end of a document. It also has seven other buttons for some of the main word-processing operations.

Begin by pressing the "menu" button: The screen displays eight numbered options for creating or editing a text, printing, formatting the screen (tabs, margins, paper length, line spacing), and working with the cassette for retrieving, saving, or deleting files. To make a selection, you watch the screen's displays for guidance and use the typewriter's number keys. I first chose 7 to see the directory of files on the cassette; then 5 to recall a file (the PWP comes with a cassette containing a "Tutor" file to get you started); then 1 to actually display the text on the screen.

From then on, most of your work is done at the typewriter. The PWP has many of the same features as the Videowriter, but the exact sequence of steps depends on the model typewriter used. Most require that you press a "code" button on the keyboard along with one other key for a special function.

For instance, on the model XE 6000 typewriter I used, pressing the "code" key and 4 key underscores every word on the screen as you type it. Pressing "code" and 2 turns off the automatic return: Words that exceed the preset right margin are not automatically wrapped to the next line. Instead, the text screen shifts to the left, allowing you to continue the line up to the maximum of 165 characters.

[Continued on page 115]

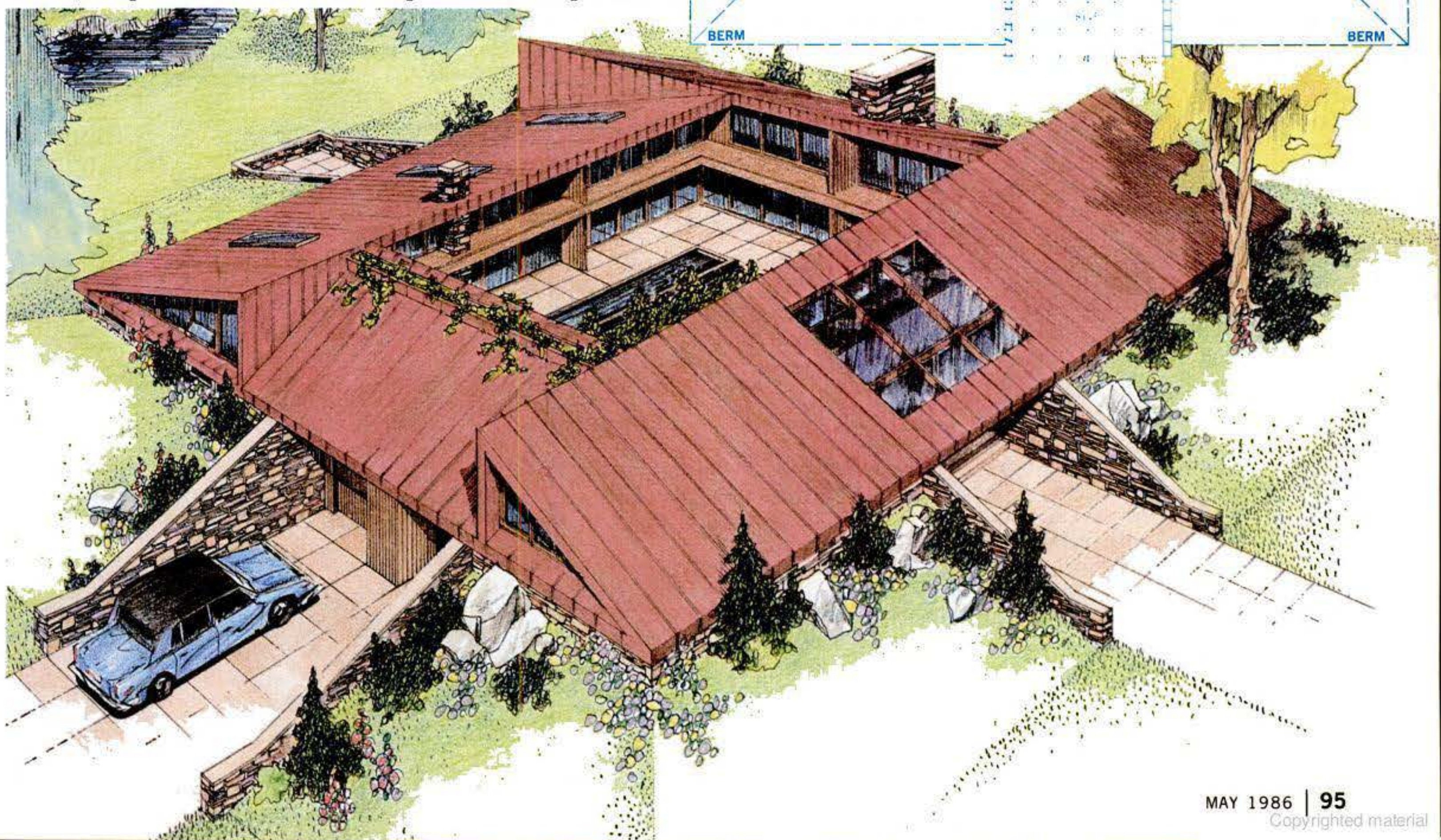
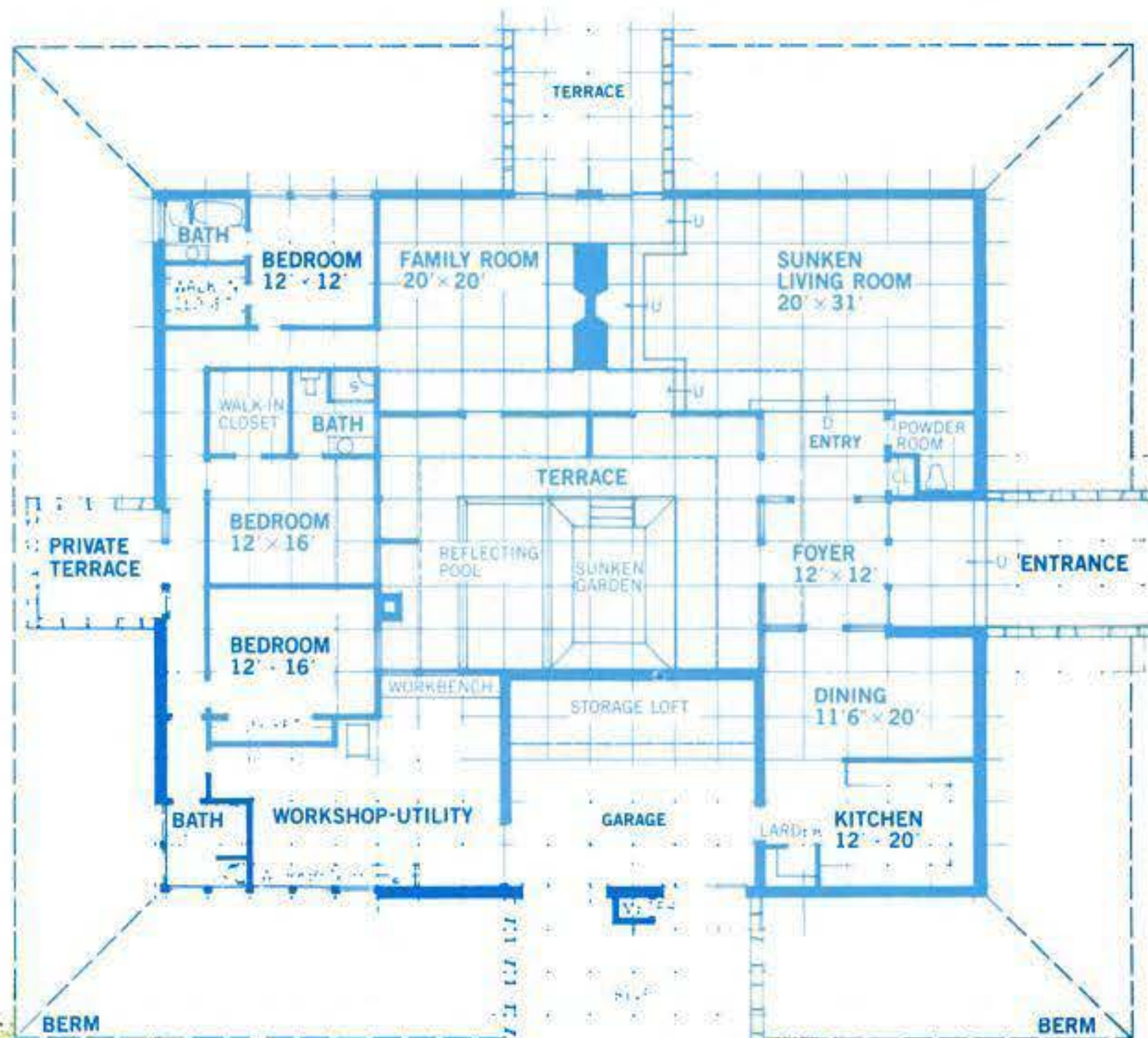
Six uncommon houses

Commissioned by PS from major architects known for innovative and energy-efficient design, all six of these striking homes can be built from available plans. In basementless versions, all but one are under 2,000 square feet in size—ideal for vacation housing.

Sweat equity is the buzzword in today's home building: Anyone planning to build a new home is well advised to pick a design that invites his participation in the construction process. So if you get involved right at the working-drawings stage, you'll find your horizon of choice greatly broadened. Commissioning an architect to draw up plans for a custom home is expensive; POPULAR SCIENCE

Continued

1. **BERMED COURTYARD** house gets its daylight illumination via skylights, sun scoops at three gable ends of the standing-seam copper roof sections, and a spacious patio bordered on three sides by stepped two-story windows. The house is ideal for either extreme of climate, where temperature swings will be modulated by the wraparound earth berm. This is earth-shelter architect Charles Woods's 10th house for PS. Designed on his usual 4-ft.-sq. modules, it is easily adjusted in size; as shown it offers 5,208 sq. ft. of space. Its concrete-block and wood-stud walls are erected on a sunken concrete slab; the roof is supported by wood trusses. The house is superinsulated and passive-solar heated; fireplaces and wood stoves provide backup heat.

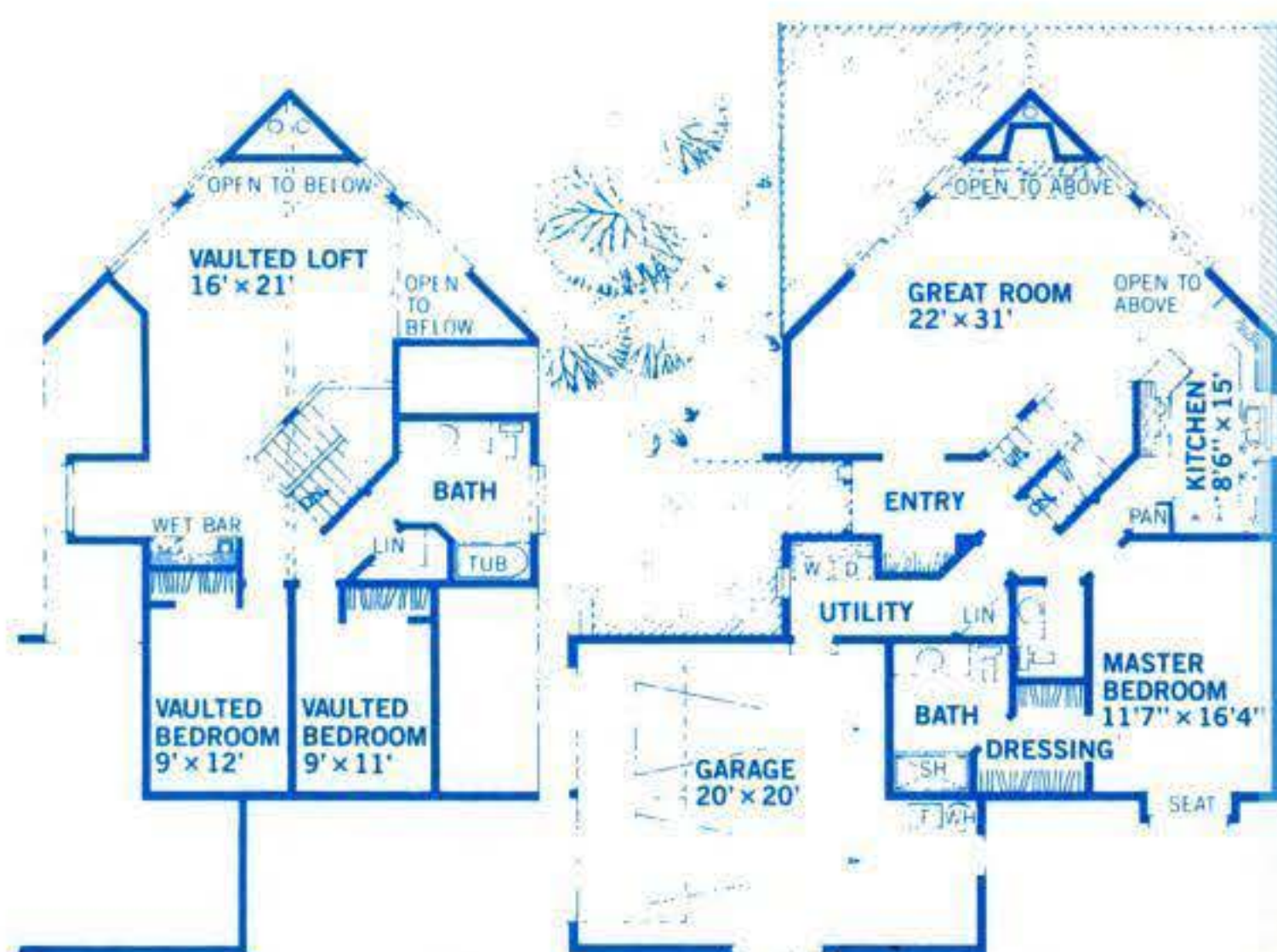




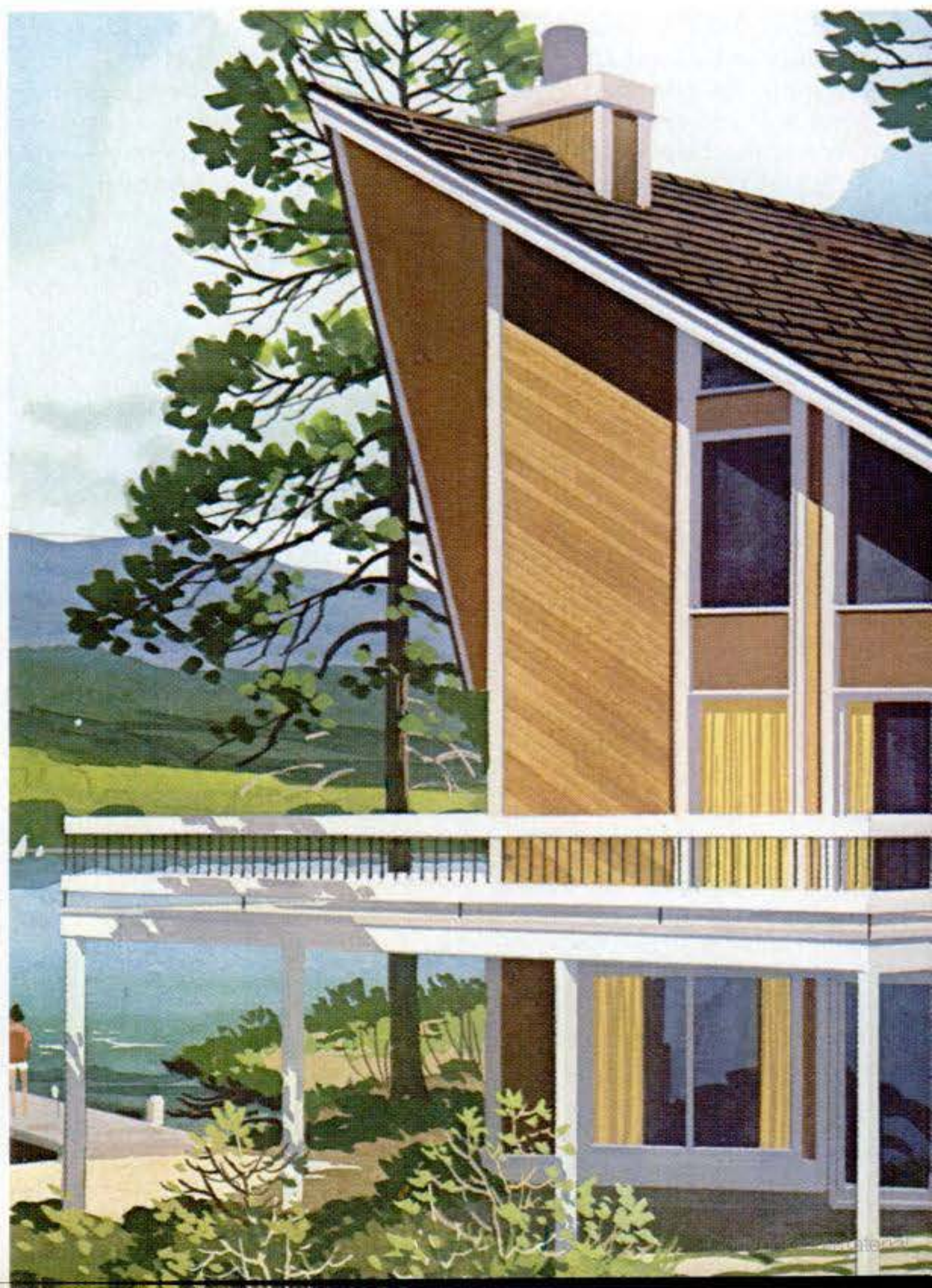
2. BIG HOUSE FOR A SMALL LOT packs a full complement of amenities into a floor plan of only 30 by 32 ft., and it “stacks up” as a lot of house where property is tight. It’s lifted out of the ordinary by cathedral ceilings, an eyebrow clerestory, and imaginative wood detailing. (Both this house and the one below were designed for PS by Ken Gephart

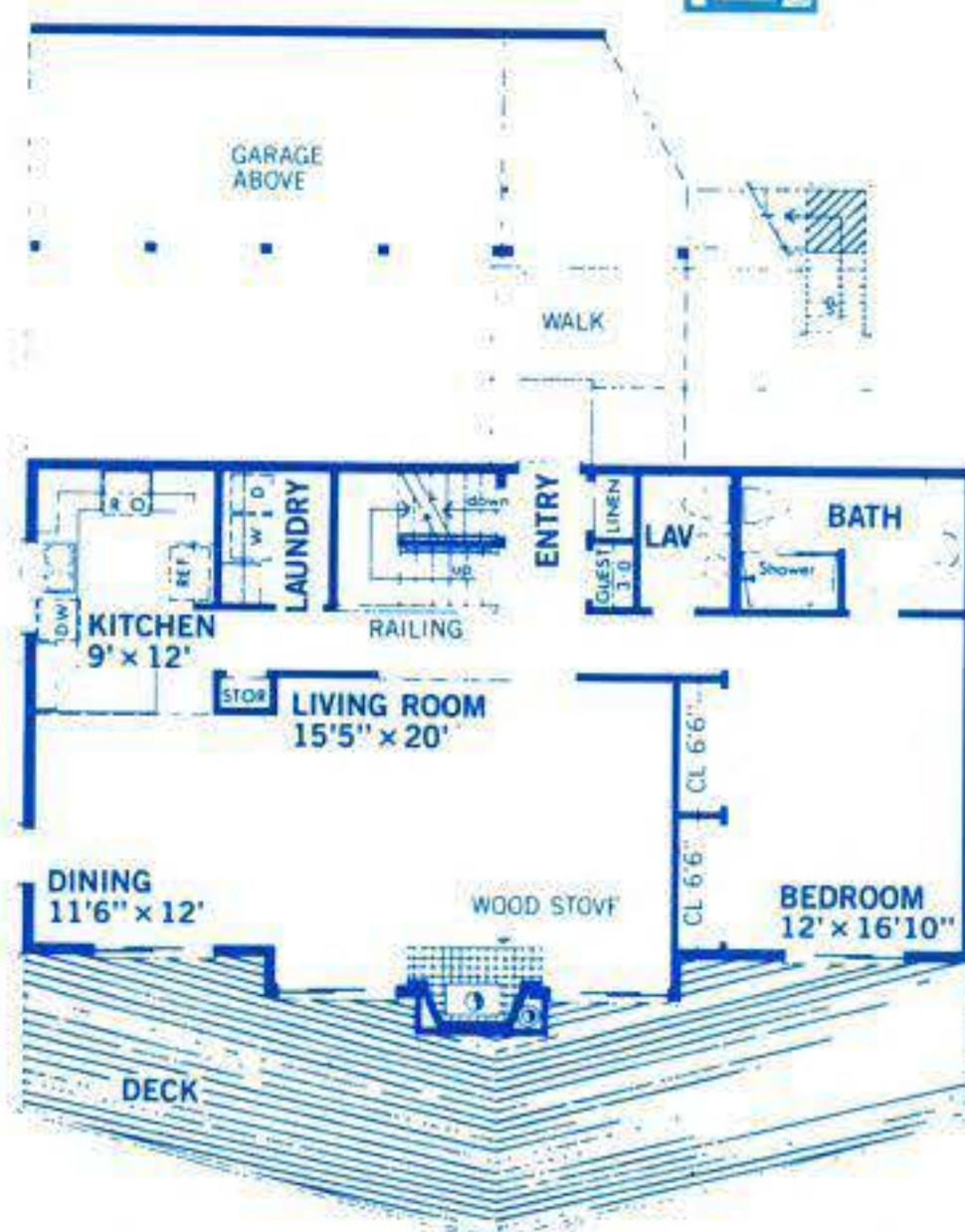
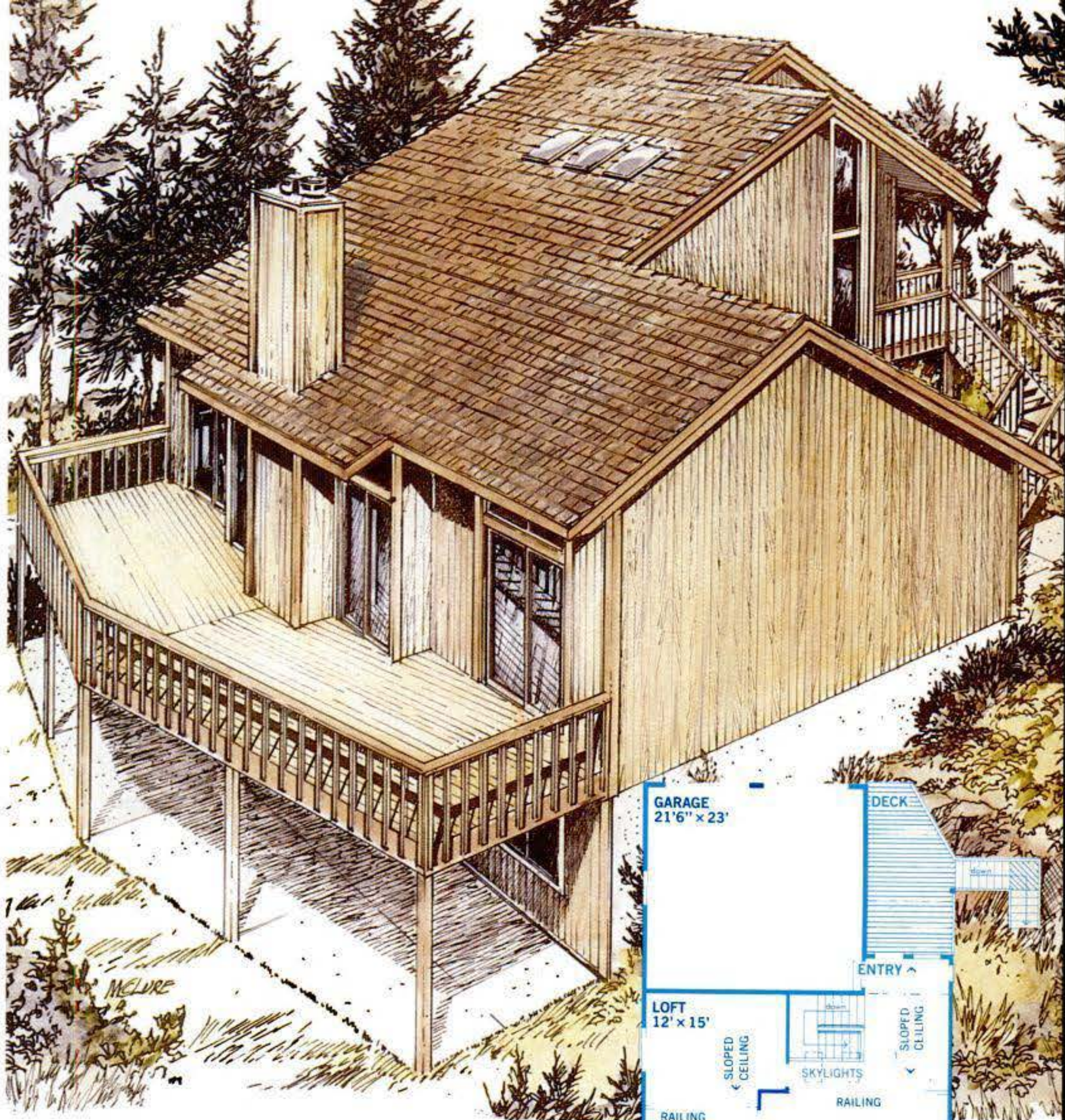
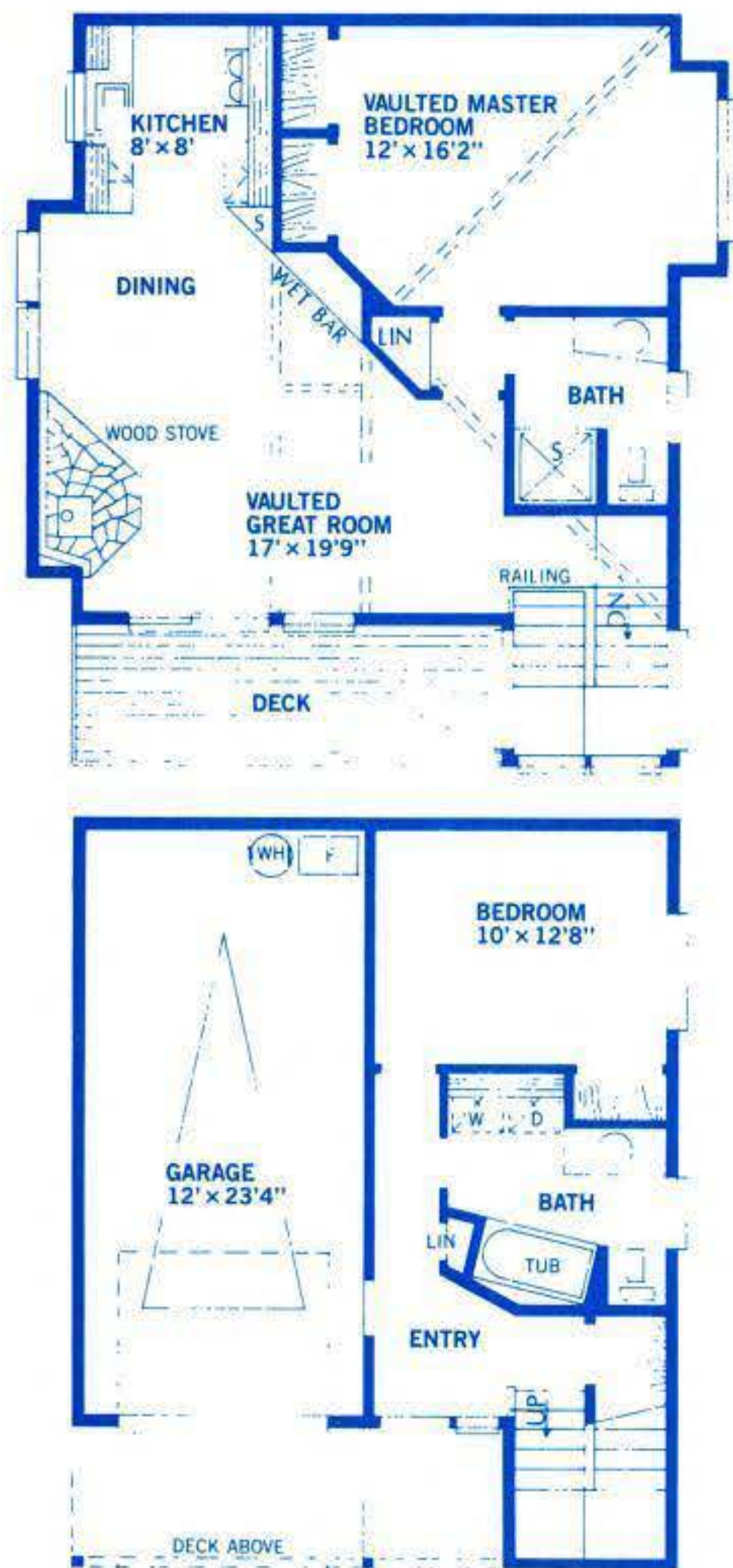
AIBD, in cooperation with Western Wood Products Assn.) Living areas are on the second floor, oriented to a broad deck to take advantage of a view. Vertical board siding and wide board trim between floors and around windows add style. The entry door on the 390-sq.-ft. lower level leads to a bedroom or up a stairway to the 770-sq.-ft. main floor.

PS home portfolio *Continued*



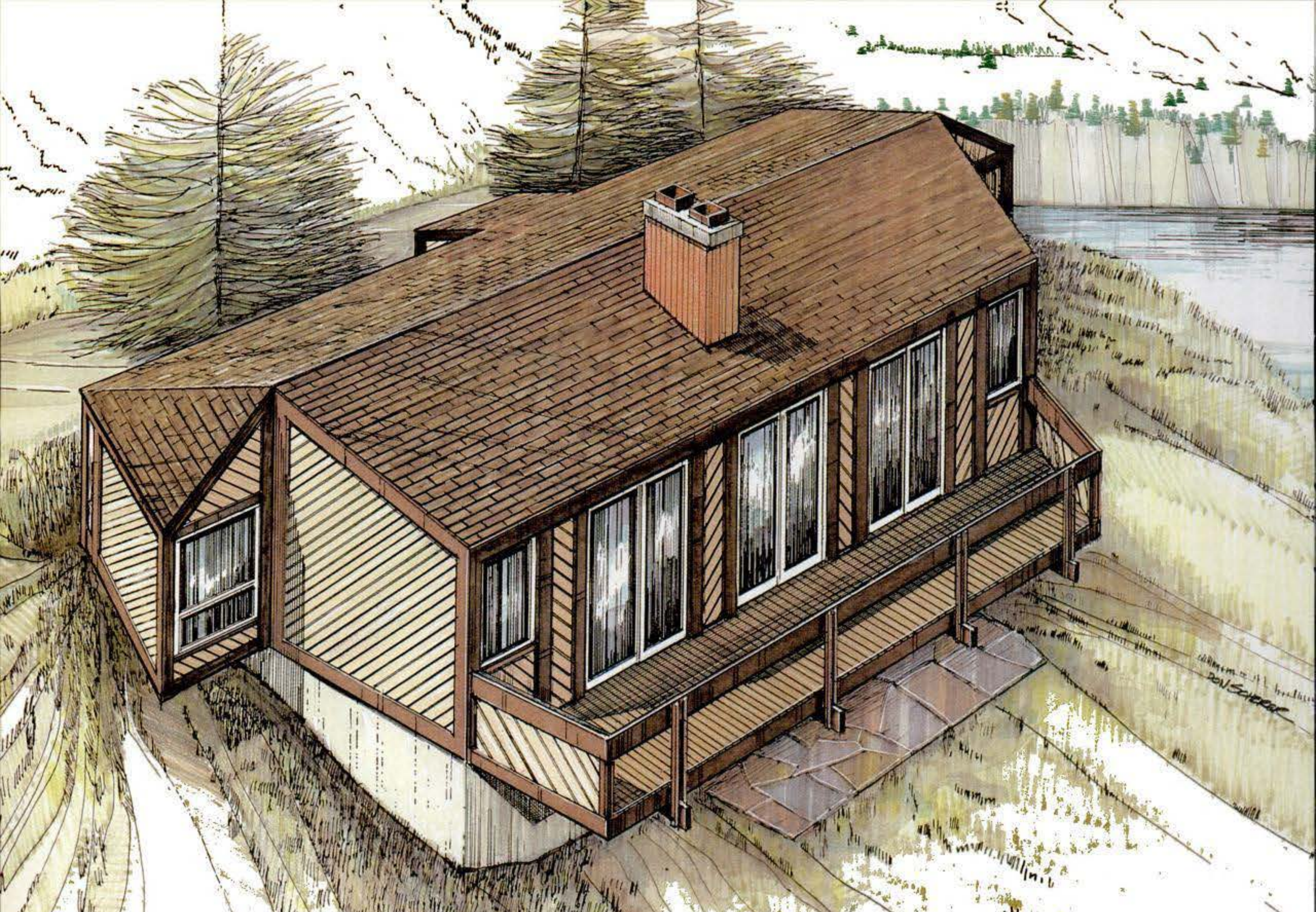
3. UPSCALE A-FRAME sports a large deck wrapped around the prow of its great room. Designed for enjoyment of a broad vista, the house has 1,004 sq. ft. on the main floor and 803 on the upper level. A daylight-basement version adds 1,004 sq. ft. of recreational and bunk space, plus storage for recreational gear. Diagonally applied 2×4 cedar decking on the entry porch establishes the pattern for the angled walls off the entry hall. Dominating the great room that occupies nearly half the main floor is a large masonry fireplace that extends two stories in the prow. All this is open to the viewing loft on the upper floor, where two bedrooms share a large bath. The master bedroom is below.





4. HILLSIDE PERCH is a three-level home designed for a 20° slope, or a fall of 15 to 17 ft. in the length of the structure. The modest roadside facade (garage doors, entry deck) belies the spacious luxury stepped down the slope. The view of the living-dining expanse from the entry loft is impressive. A U-shaped kitchen is closed off by a snack bar. Tucked under the deck is a daylight basement (no floor plan shown).



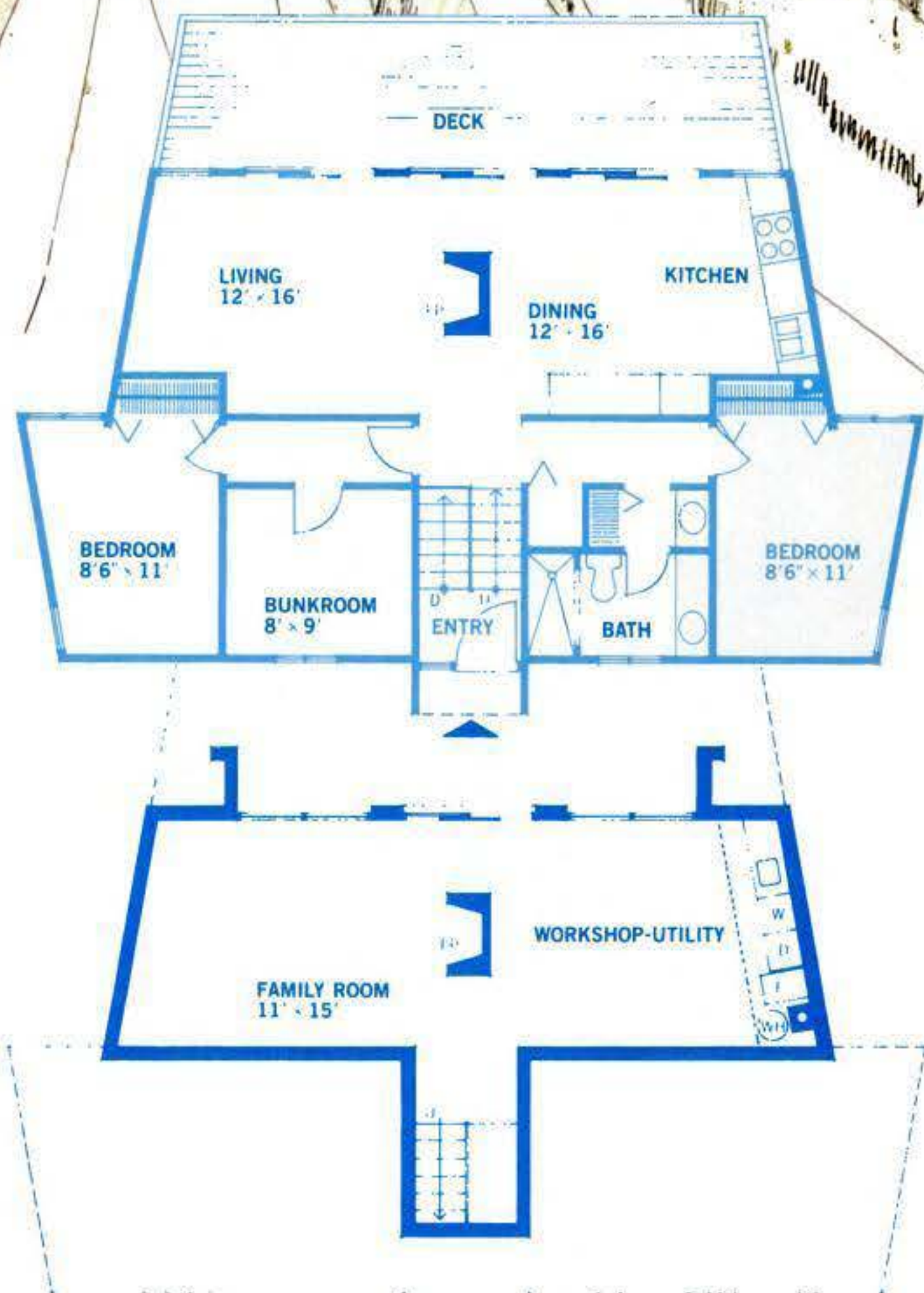


5. DOUBLE WEDGE, on a sloping site, can be built with a partial or full basement. The split-level entry gives access to either level: the game room and workshop-utility area downstairs or the living-dining-sleeping floor upstairs. The "butted wedge" floor plan gives a view to every major room. The living area has a sloped beamed ceiling and is divided from the dining-kitchen area by an island fireplace. (A second fireplace is below that.) Three sliding glass doors open onto a full-length deck for alfresco dining and sunning.

How to order plans for the house of your choice

Plans data, listed in the same order that the houses appear above:
1 A set of detailed plans for the Bermed Courtyard house is \$150; each additional set is \$25. MasterCard and Visa orders are accepted. Address: Charles G. Woods, RD 3, Box 538, Honesdale, Pa. 18431.
2 and 3 A set of professionally drawn plans for either house is \$100; four sets are \$150. Write Piercy & Barclay Designers, Inc., Studio 103, 7080 S.W. Fir Loop, Suite 100, Tigard, Ore. 97223; to use MasterCard or Visa, call toll-free (800) 772-7225. Specify PS535-4D for Big House for a Small Lot; PS534-2A (no basement) or PS534-2D (daylight basement) for Upscale A-Frame. Mirror-reverse plans are available; materials list is \$30; specs, \$20.
4 A set of plans for the Hillside Perch is \$160; four sets, \$195. Write Home Building Plan Service, 2235 N.E. Sandy Blvd., Portland, Ore. 97232; for MasterCard or Visa orders, call toll-free (800) 547-5570. Specify plan number 966-1B. Mirror-reverse plans are \$10; materials list, \$30; plumbing and wiring diagrams, \$7.50 each.
5 and 6 Construction plans for either the Double Wedge or the Pinwheel House are \$75 a set or \$105 for three. Send your check to Princeton Plans Press, Box 622, Princeton, N.J. 08540; for MasterCard or Visa orders, call (609) 924-9655. A catalog of additional designs, titled "The Uncommon House Collection," is \$5.

When ordering any plans from this PS home portfolio, please add \$5 for postage and handling.



PS home portfolio *Continued*

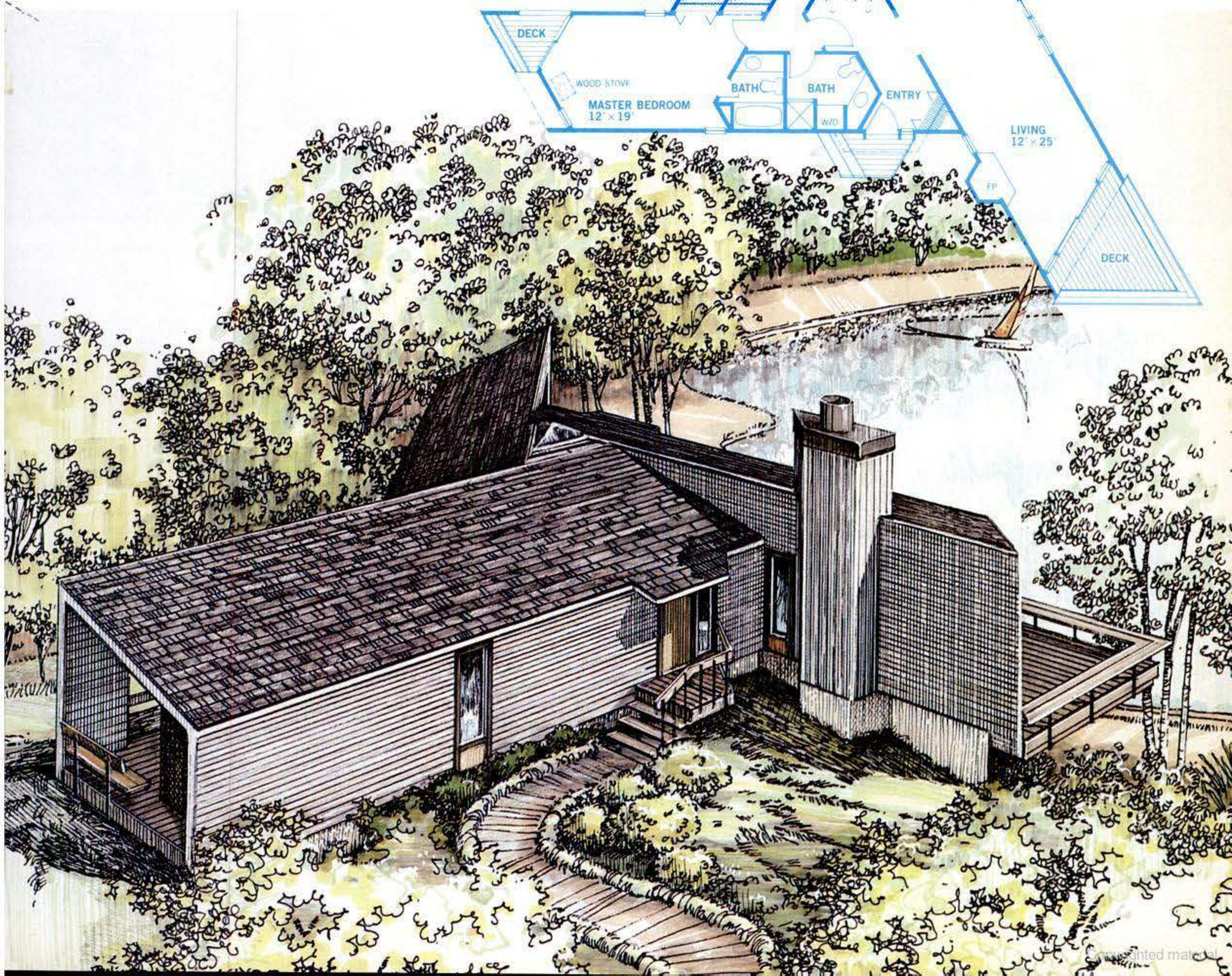
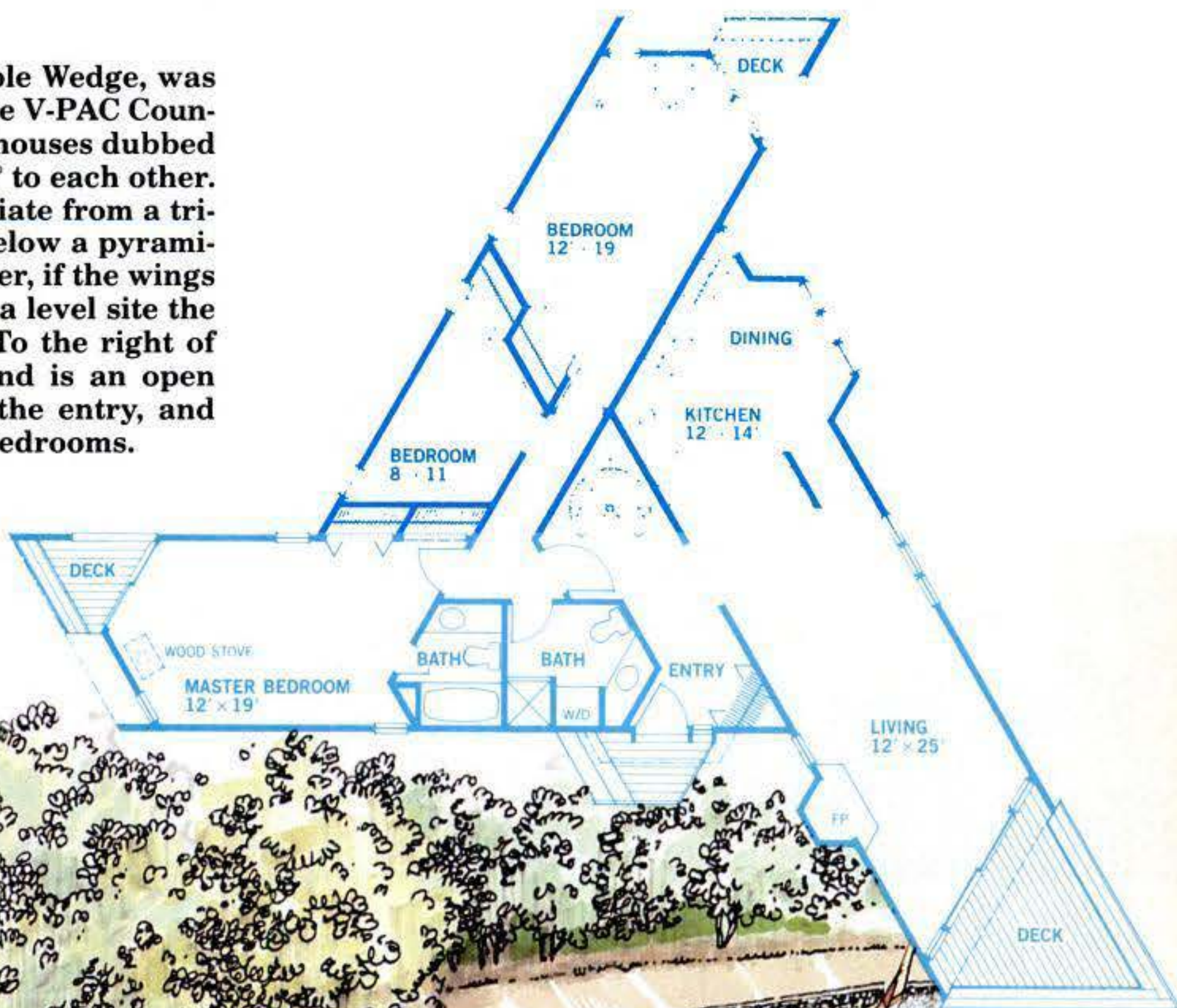
has done this for you, asking for truly original designs from four sources well-known for mastery of specialty housing. If you choose a house you can help build, like one of the six shown here, you'll speed the process and save a bundle. And you'll end up with a unique home, customized to your family's lifestyle.

Although the houses in this portfolio are all shown in vacation settings, most could fit onto suburban or rural lots. Their plans are all easy for a novice builder to understand and evaluate.

These homes grew out of the Leisure Home of the Month series PS launched in March 1973 with the Two-Phase Twin Ridge plan created by Robert Martin Engelbrecht for the

V-PAC Council. The council was a group of major building-material manufacturers promoting quality in second-home design, and Engelbrecht was PS's sole source for the first two years' houses. By that time, the series had attracted the attention of many other designers specializing in vacation housing, and PS had its pick of the best for 13 years. The series terminated with the March issue, and further publication of house plans in PS is likely to take the form of an annual portfolio such as this one. (I borrowed my headline from Engelbrecht's new plans catalog, "The Uncommon House Collection for the Uncommon Man"—see ordering box.) If you've an idea for the type of designs you'd like to see in future portfolios, let me know.—*Al Lees*

6. PINWHEEL HOUSE, along with the Double Wedge, was designed by Robert Martin Engelbrecht for the V-PAC Council (see text above). This is one of a series of houses dubbed "Sixty Plus" because wings are placed at 60° to each other. In the case of the Pinwheel, three wings radiate from a triangular core containing a spiral staircase below a pyramidal skylight. The stair is only needed, however, if the wings are built over a partial or full basement; on a level site the wings could be erected on concrete slabs. To the right of the entry hall is the living room; at one end is an open kitchen with a dining bay. Turn left from the entry, and you pass a bathroom on the way to three bedrooms.





Four fanciful fences you can build

Fences are often viewed as enclosures, not architecture. However, the intriguing designs of these four working fences—three redwood and one reed—show that they can be decorative, indeed. They can also blend with the surroundings or sculpt sun and shade to create a quiet corner.

By **RICHARD LAYNE**

Drawings by Eugene Thompson

Sing a song of the American fence, and you'll find that the harmony's there but you're short on melodic variations.

The harmonic line comes from the standard picket, board, or post-and-rail fences, which can supply privacy, act as a windbreak, or cordon off an area, clearly delineating mine from yours. They're all functional, but hardly architecturally arresting. There's not a rhapsodic melody among them.

That's where this sampling of fanciful yet functional fences comes in. These four easy-to-build fences can be erected on level or sloped ground. And each features an intriguing design

that also influences its surroundings.

The slat-shaded arbor built into fence No. 2 sculpts sun and shade to create a light-defined cozy area. And the curbside portion of the planter-box fence (3) holds greenery and flowers to integrate the yard and structure. A low fence, it invites a cheery greeting from passers-by.

Which fence is right for you? If you only want to outline an area, consider the planter-box fence. The other fences can all ensure privacy—your choice depends on your needs.

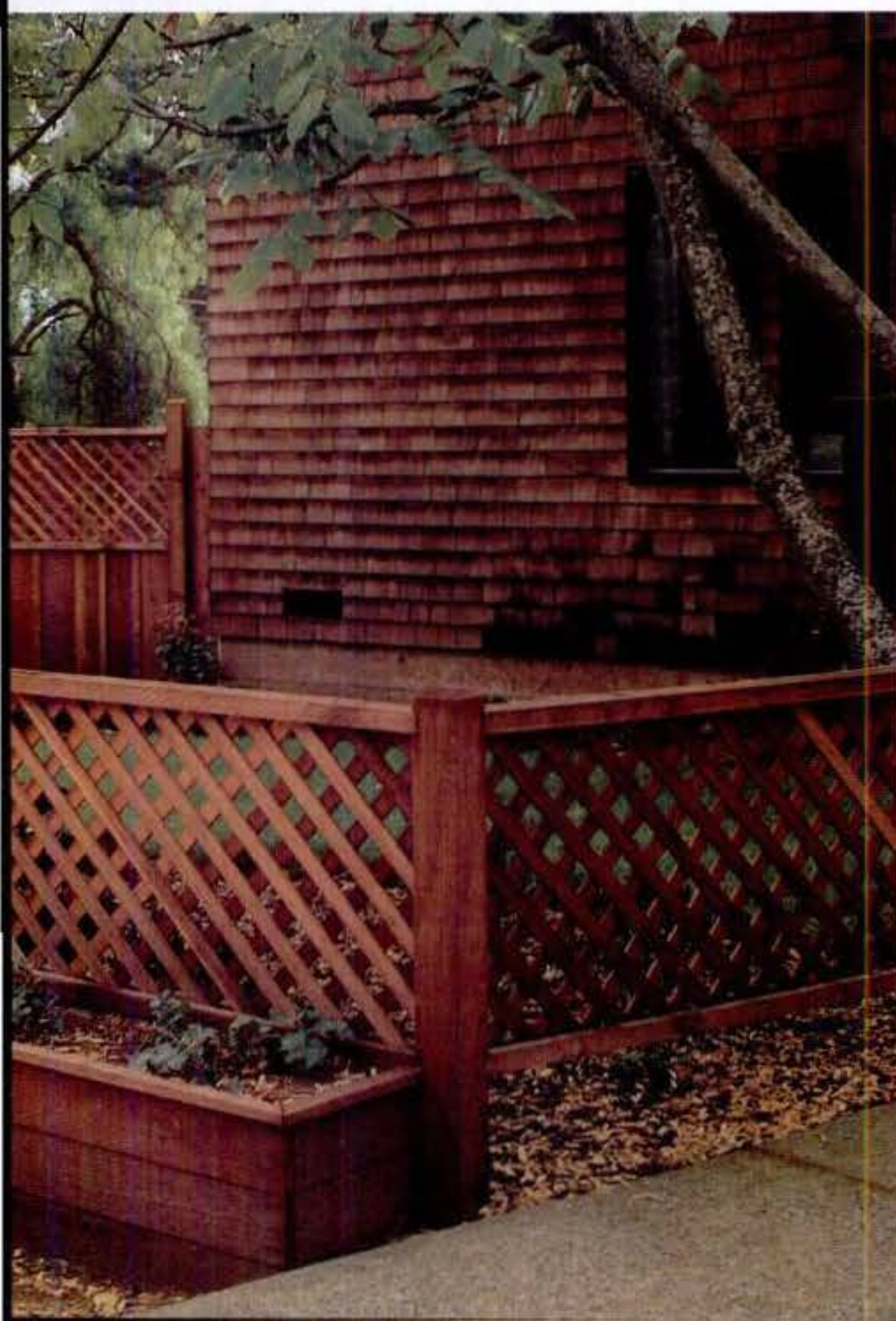
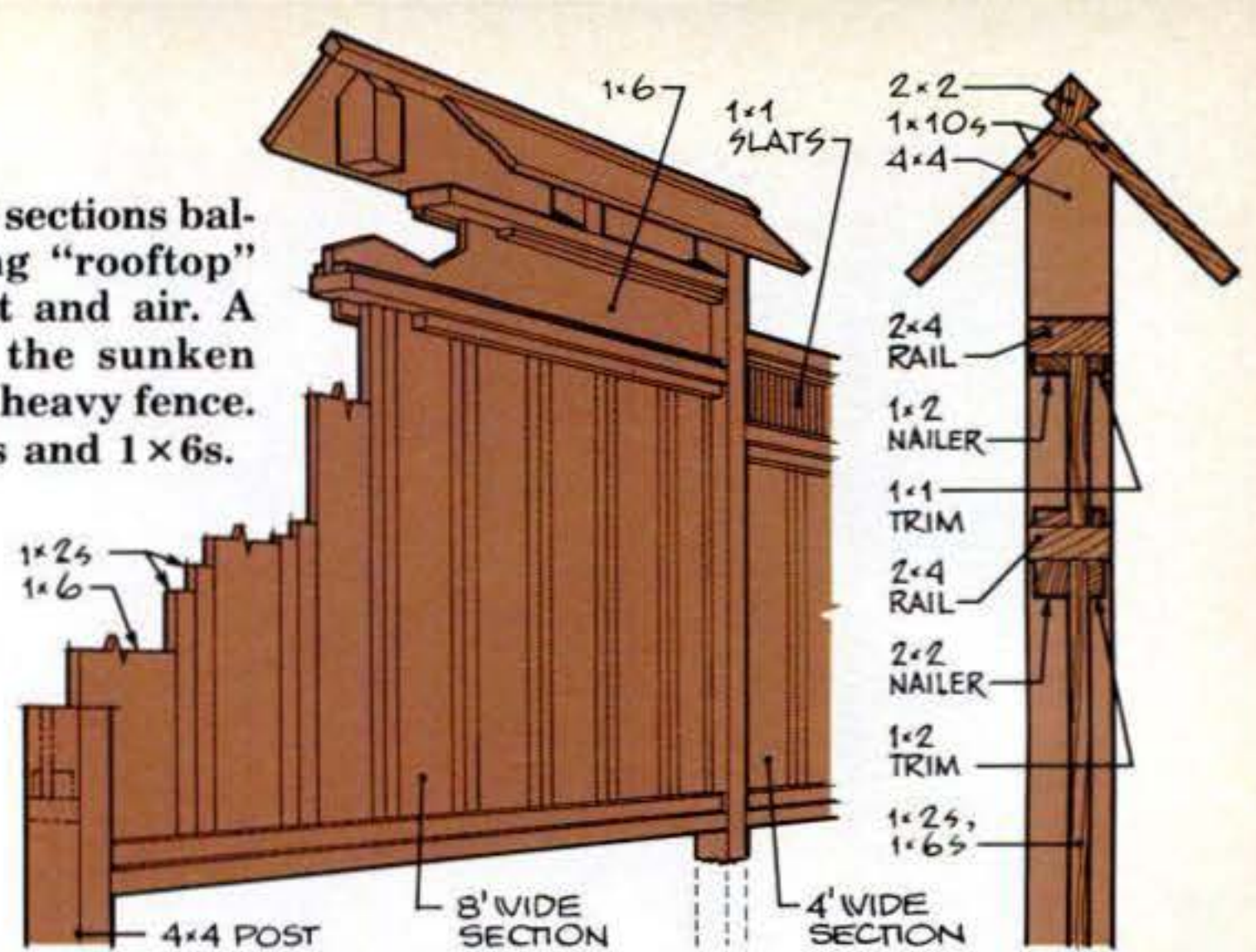
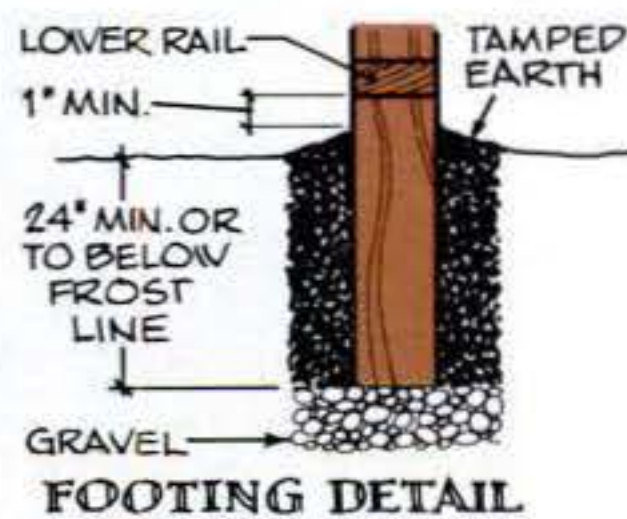
Building a privacy fence means making a trade-off between ventilation and seclusion. Erect too heavy a structure, and you risk creating an airless outdoor room. But you'll need

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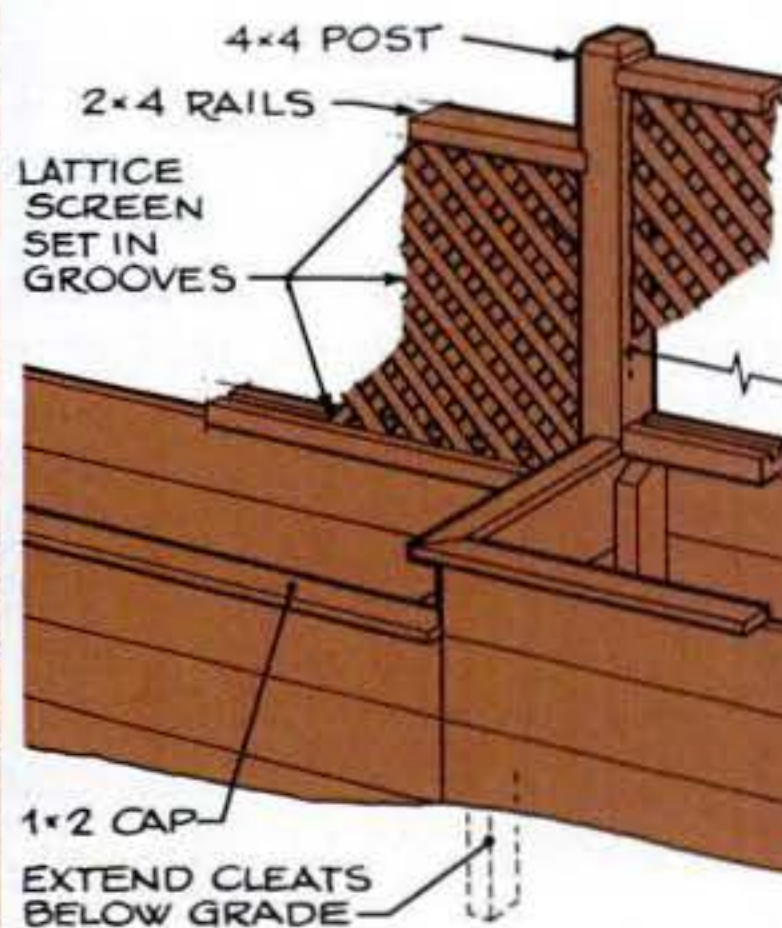
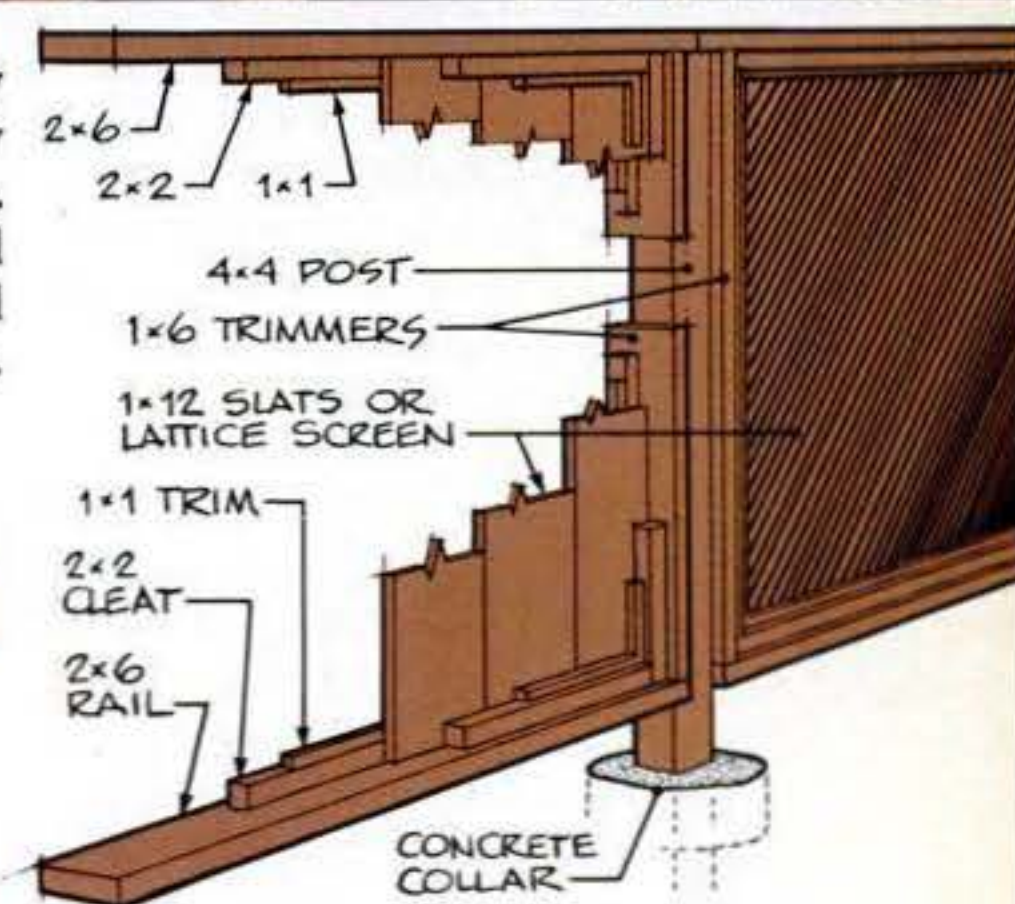
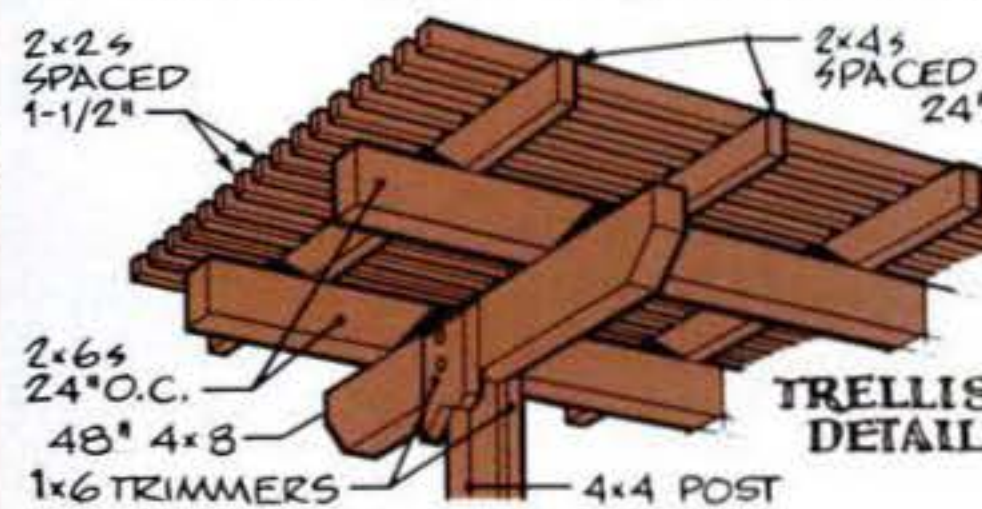




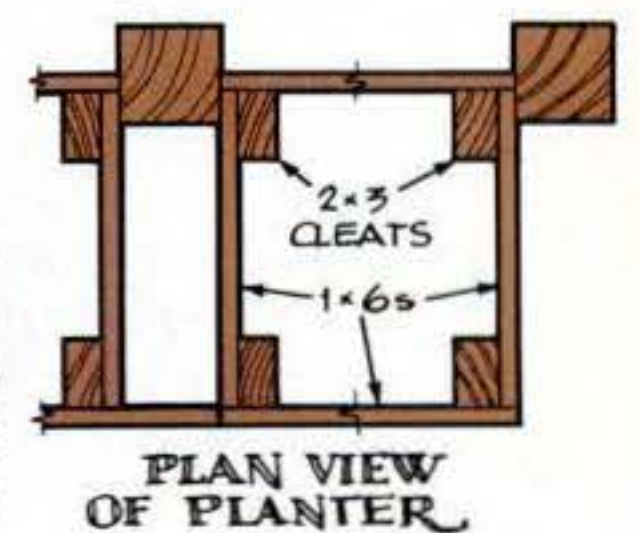
1 Four-ft.-long slat-topped sections balance the rugged 8-ft.-long "rooftop" segments and admit light and air. A concrete collar around the sunken posts adds stability to the heavy fence. Note the alternating 1x2s and 1x6s.

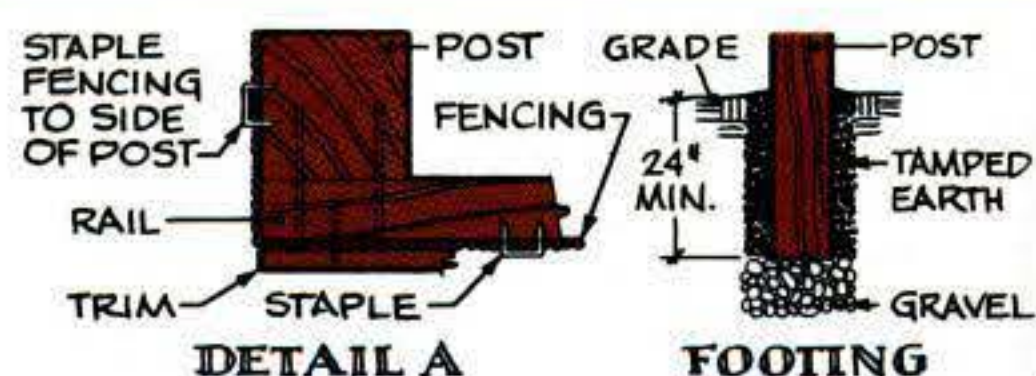
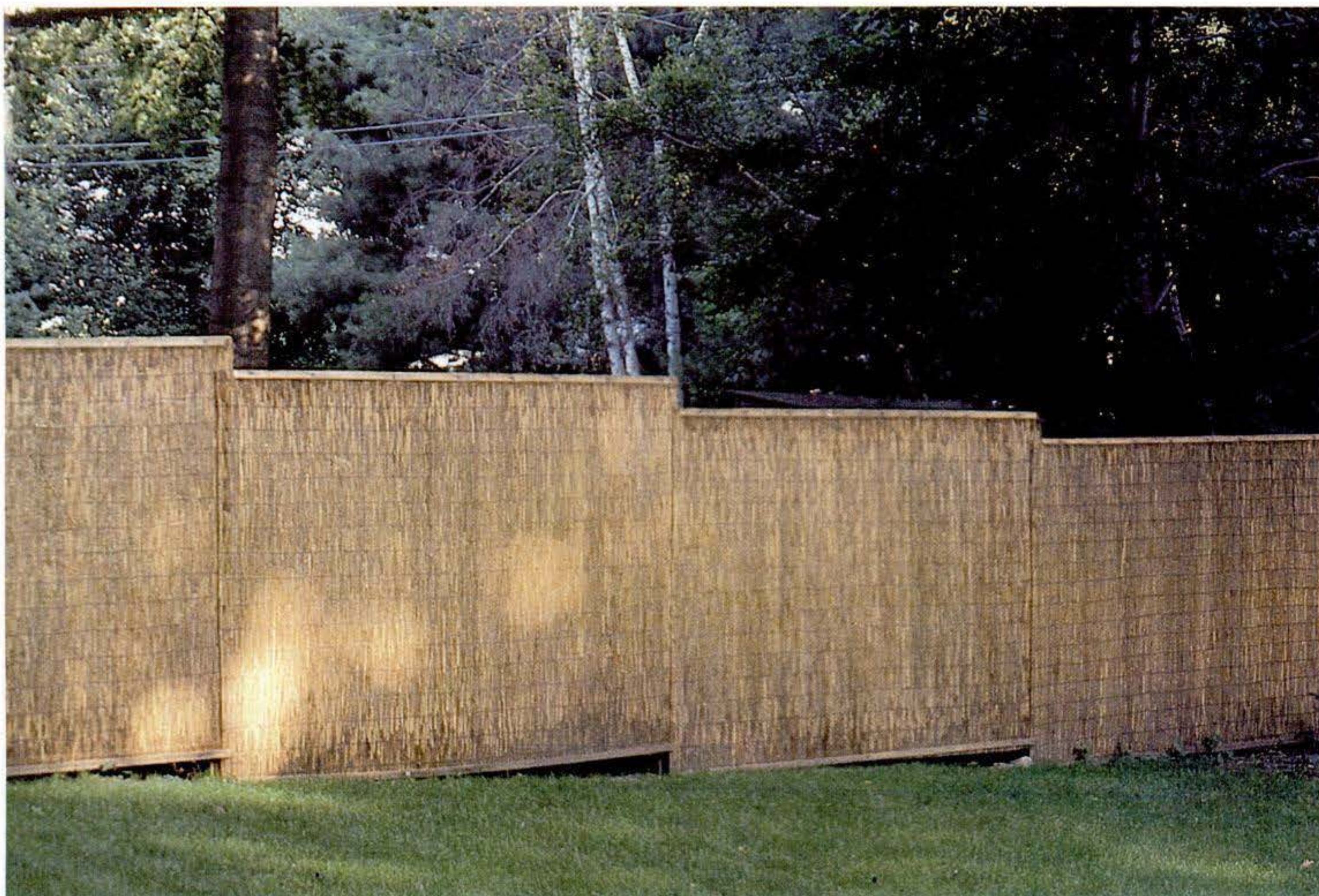


2 Oriental-like overhang's carefully laid slats help mold sun and shadow to create a restful poolside hideaway. The gridded superstructure is anchored to a lattice fence, which wraps around to create a light and airy outdoor room.

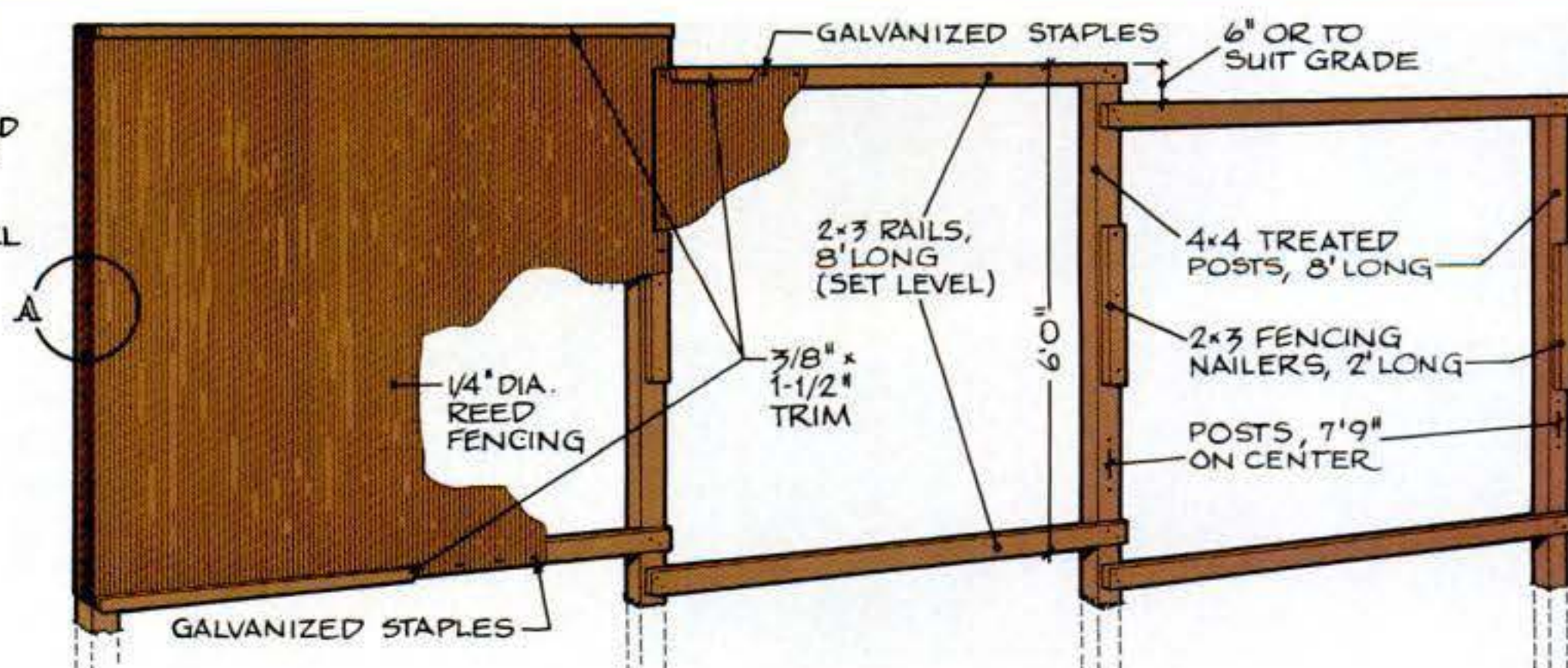


3 Sturdy planter boxes anchor the low part of the fence. Note the mitered cleat top, which helps hide the nailers. The higher portion of the fence, with solid-board bottom, ensures privacy while continuing the lattice pattern.





4 Fence posts are often set 8 ft. apart, but here they're 3 in. closer to allow for panel overlap. For a finished look, wrap the fencing around the first post. Tamped-earth backfill provides sufficient support for a light fence.



a sturdy windbreak for a wind-swept site. The more a fence cuts off wind, the stronger it must be.

Fence No. 1, for example, is an impressive windbreak. On the other hand, wind filters through the reed fence (4), so the fence will temper a strong breeze but won't cut it off. This fence's delicate texture and structure help it blend in with a well-kept yard. If you want to create a shaded outdoor room, consider fence No. 2, with its lattice canopy.

To erect any fence on a slope, think in terms of building a staircase. First determine the structure's length. Then figure out how far the fence has to drop by calculating the distance between the slope and the horizontal plane. Average that distance over the number of proposed panels to make

each step down of equal height. There is no prescribed step height—it must be matched to the grade.

Panel fences are usually built in six- or eight-foot-long segments. This aesthetically pleasing dimension coincides with precut lumber sizes, so you can save time and avoid waste by using pieces that require little cutting.

The reed fence's panels should also be a conventional length. In this case, though, it's more a matter of looks than saving money. The fence panel here is 1/4-inch-diameter reed woven together with vinyl-covered steel wire and stapled to the frame. The designer purchased the six-foot-high fencing in 15-foot-long rolls from Montgomery Ward; it's also available in many lawn-and-garden supply stores. The 24-foot-long fence cost \$70 to erect.

A word on wood care: Left untreated, redwood weathers to a driftwood gray. You can assist Mother Nature by coating the boards with a bleaching oil or stain, which brings on a uniformly weathered look. If you prefer your redwood pristine, coat the boards with a clear sealer. This will arrest the natural color at a buckskin tan and allow the grain to show through. If your fence is to be in a moist, shaded area, buy a sealer or stain with a mildewcide. A reed fence weathers to an eye-soothing silver-gray.

If you're interested in building a redwood fence, you might find two 50-cent booklets from the California Redwood Association (591 Redwood Highway, Suite 3100, Mill Valley, Calif. 94941) helpful: "Fences" and "Tips for Garden Projects."

How to dowel almost anything

For strong, efficient joints in wood, the home craftsman often turns to dowels—largely because of the many commercial jigs available to aid precision. But for some woodworking applications, homemade jigs are best. The design of the particular joint determines which jig to use.

By **THOMAS H. JONES**
Drawing by *Gerhard Richter*

Strong dowel joints require good design and careful construction. And when they are made properly, dowel joints can be as strong as the much-harder-to-make formed joints

such as mortise-and-tenon or dovetail.

The important thing to remember is that the holes in the joined pieces must mate and be aligned perpendicular to the mating surface. The proper jig can help you make sure that holes are accurately aligned.

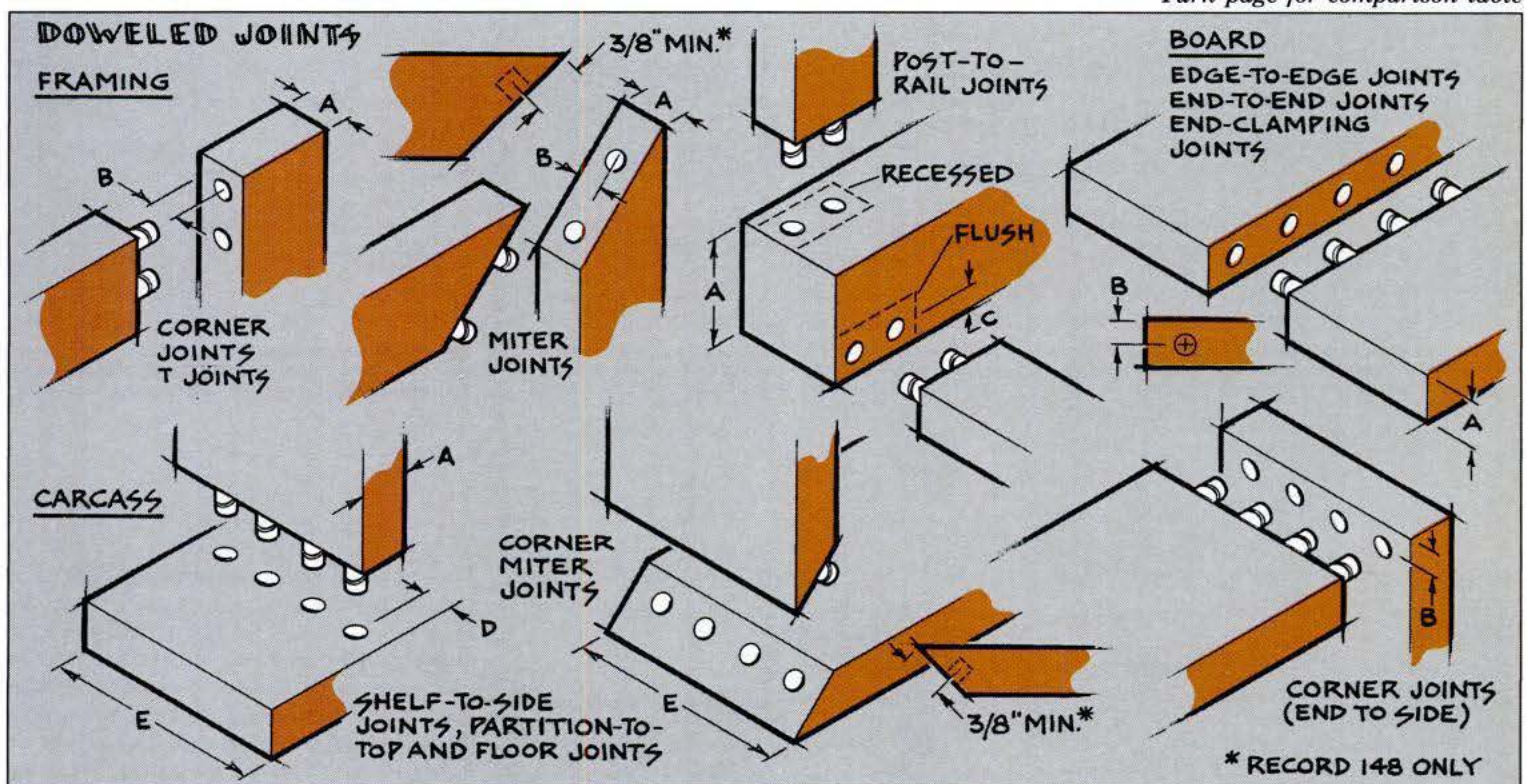
Jigs come in many forms. Some are better at certain jobs, some at others.

And some perform a wider variety of jobs than others.

The first step in evaluating any jig is to sort out the applications. The table on the next page lists six main categories of jigs and indicates which of the joints illustrated can be made with a particular jig. Which jig you

Text continued on page 108

Turn page for comparison table



Careful planning is vital for producing strong dowel joints, and precise measurements ensure alignment (see table for definition of measurements A through E). The wide variety of dowel joints shown are all designed according to the following principles:

1. A dowel joint requires a minimum of two dowels. A joint with one dowel would be easily twisted, leading to either glue-line failure or dowel fracture.

2. The diameter of the dowels should be one-third to one-half the thickness of the wood being joined. If the pieces are of different thicknesses, the dimension of the thinner piece should determine the dowel diameter.

3. For edge-to-edge joints, the dowels should penetrate each piece $1\frac{1}{4}$ times the thickness of the wood (with the thinner piece determining hole depth). Deeper penetration into end grain doesn't add materially to joint strength, and deeper penetration into side grain results in higher stresses on glue line because of different expansion rates.

4. The total depth of a pair of mating holes should be $\frac{1}{8}$ in. more than the dowel length. The last thing you want is a dowel butting the bottoms of the holes before the joint is closed.

5. In furniture-frame construction, dowels in end grain should be one

diameter clear of the edges of rectangular members and at least one-half diameter away from the sides. These precautions will help avoid splitting the wood when you assemble the joint. Dowels in side grain near the end of a piece should be two diameters clear of the end when possible.

6. When doweling board ends to board sides, keep dowels at least two diameters from edges to reduce splitting. Dowels in the board side must be close-spaced because of the short penetration into the side.

7. Unless you have some good reason for not doing it, locate dowels on the long center line of a joint.

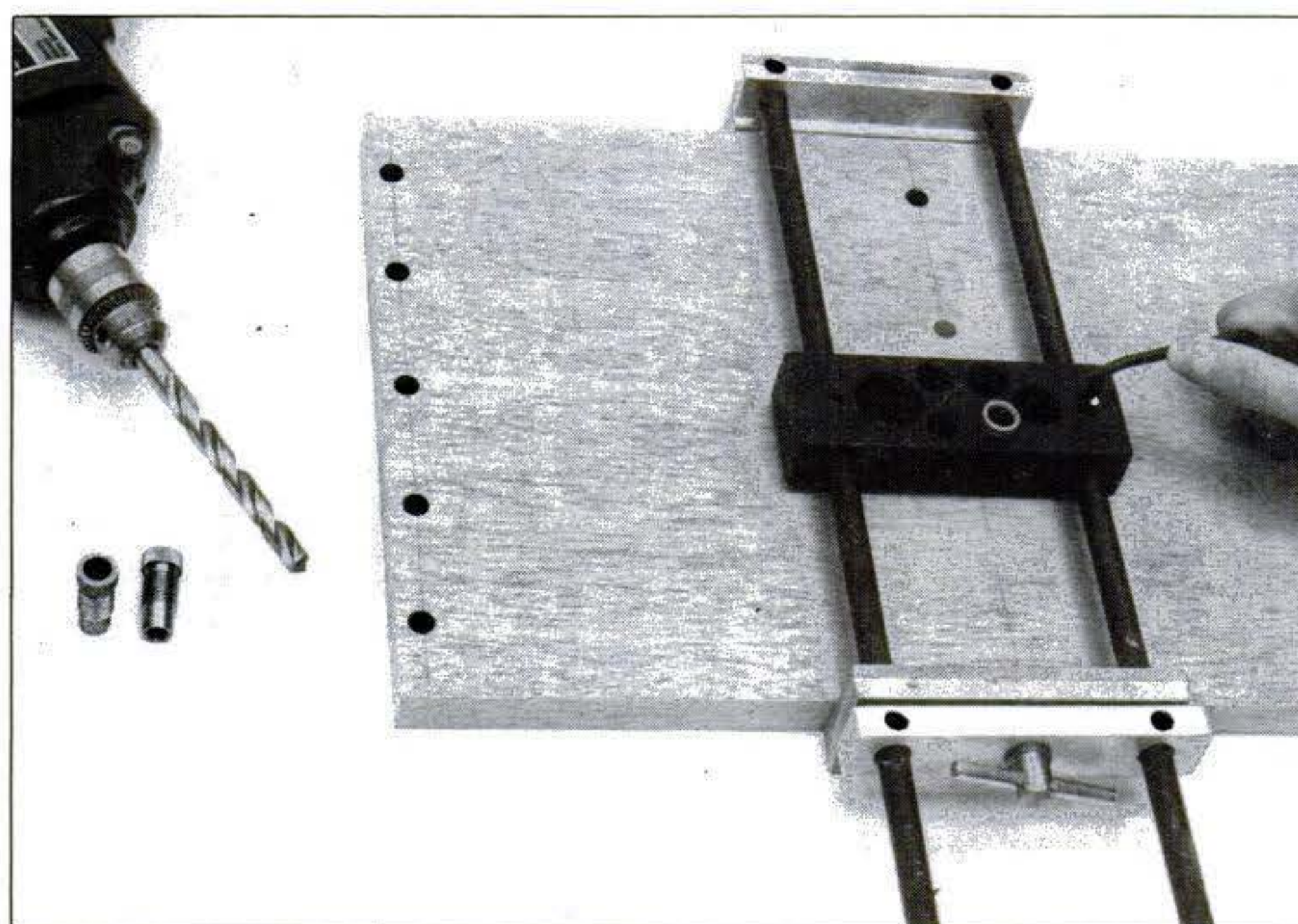
PS dowel-jig comparison table

DOWEL-JIG CAPABILITY	DOWEL JIG, HOLE SIZES (IN.)	COST (\$)	FRAME JOINTS			BOARD JOINTS	CARCASS JOINTS			A	B	C	D	E
			CORNER OR T	MITER	POST-TO-RAIL	EDGE-TO-EDGE OR END-CLAMP	CORNER	SHELF-TO-SIDE OR PARTITION	CORNER-MITER	WORK THICKNESS (IN.) ¹	DOWEL OFFSET (IN.) ²	DOWEL OFFSET (IN.) ³	DOWEL OFFSET (IN.) ⁴	STOCK WIDTH (IN.) ⁵
Accurately position your drill a set distance from an edge; you manually adjust the jig position along the edge to a pencil mark	Dowl-It 1000 1/4, 5/16, 3/8, 7/16, 1/2	33	●	●						3/8 min., 2 max.	On C/L	n.a.	n.a.	n.a.
	Dowl-It 2000 1/4, 5/16, 3/8, 7/16, 1/2	40	●	●						3/8 min., 2 max.	On C/L	n.a.	n.a.	n.a.
	Stanley 59 3/16, 1/4, 5/16, 3/8, 7/16, 1/2	42	●	●		●				No min., 2 7/8 max.	No limit	No limit	No limit	2 7/8 max.
	U.S. General 840 3/16, 1/4, 5/16, 3/8, 7/16, 1/2	28	●	●		●				No min., 4 max.	No limit	No limit	No limit	4 max.
	Vermont American 7910 1/4, 5/16, 3/8	7	●							1/2 min., 2 max.	On C/L	n.a.	n.a.	n.a.
Accurately locate your drill in selected positions across the width of a workpiece perpendicular to the edge after you set the jig position along the edge of the workpiece	Dowl-It 4000 1/4, 5/16, 3/8, 1/2, 5/8, 3/4, 1	80						●		n.a.	3/8	3/8	3/8	12 max., no limit
	Record 148 1/4, 5/16, 3/8, 6 mm, 8 mm, 10 mm	52						●		6 max.	No limit	No limit	No limit	6 max., no limit
	Stanley 59 (see above)							●		—	—	—	—	—
	U.S. General 840 (see above)							●		—	—	—	—	—
Simultaneously locate mating holes in both pieces and position your drill	Disston 5243 1/4, 5/16, 3/8	20					●			2 max.	On C/L	n.a.	n.a.	n.a.
	Leichtung 6742 1/4, 5/16, 3/8	22					●			2 max.	On C/L	n.a.	n.a.	n.a.
Locate the holes across and along the workpiece; transfer these two-axis locations to the second piece and position your drill	Record 148 (see above)		●	●	●	●	●	●	●	—	—	—	—	—
Locate the holes in the first piece on the edge center line, then, using dowels inserted in these holes as a reference, locate mating holes in the second piece and position and guide your drill	Disston Dowel Magic 1/4, 5/16, 3/8 (separate jigs)	9 - 11 each	●	●			●	●		No min., 1 1/4 max.	On C/L	n.a.	No limit	No limit
	Wolfcraft Dowelmaster 1/4, 5/16, 3/8, 7/16, 1/2 (separate jigs)	20 each	●	●			●	●		No min., 1 1/4 max.	On C/L	n.a.	No limit	No limit
Locate holes to mate with existing holes, and locate, but do not guide, your drill	Dowel centers 1/4, 5/16, 3/8, 7/16, 1/2, 3/4	3 - 5 per set	●	●		●	●	●		—	—	—	—	—

NOTE: Jigs are grouped according to how they locate your drill for drilling initial and mating dowel holes. Some jigs appear in more than one group because they can be used in more than one mode. Costs are

not list prices but reflect a composite of going prices; ● indicates jobs jigs can do without undue stress; ¹ maximum and minimum stock thickness jig can hold; ² minimum dowel-center-line distance from edge of stock;

³ minimum dowel-center-line distance from reference edge; ⁴ minimum dowel-center-line distance when doweling wide side of stock; ⁵ maximum stock width—"No limit" applies when accessory rods are used



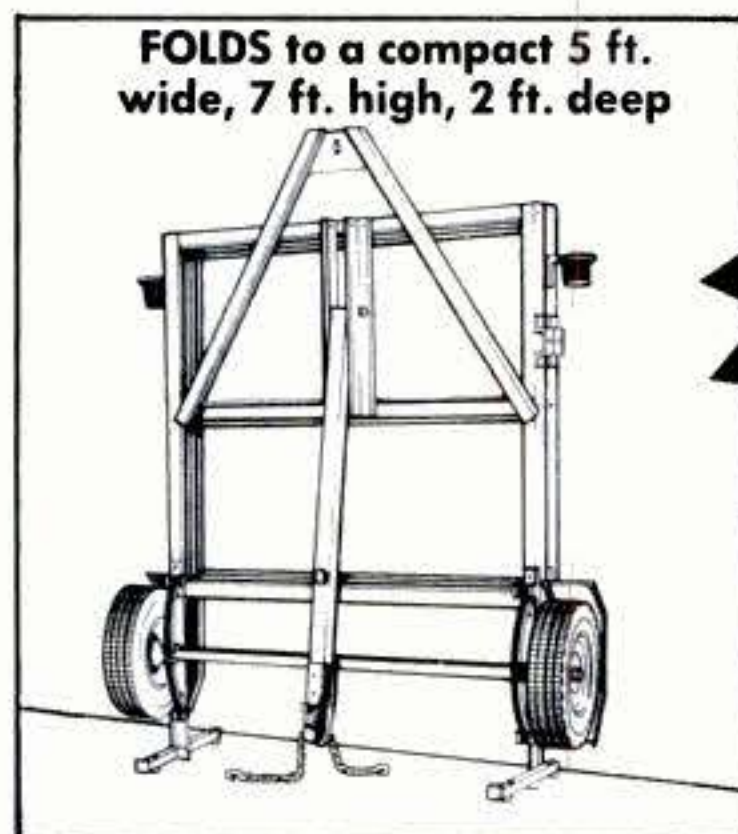
Dowl-It 4000 wide-board jig (left) will locate dowel holes anywhere on the face of stock up to 12 in. wide. Wider stock can be accommodated if you replace rods with longer 7/16-in. cold-rolled steel rods. You could, in fact, set up the jig to locate dowel holes anywhere on a 4-by-8-ft. sheet of plywood. And the jig will locate a pair of holes on 3/4-in. centers, aligned along the board.

Index marks for aligning the work are quite visible on this jig—unlike the other jigs in the Dowl-It group (see the table). Deep (though not as deep as the 1000 and 2000 jigs) drill-guide holes help you keep the drill perpendicular to the work surface for smaller holes. The jig should be used with a drill press when drilling 3/4- and 1-in. holes in order to maintain drill-feed control. You can clamp the jig to the workpiece and move the drill block to positions across its width, or keep the block fixed and move the jig along workpiece. But the jig is awkward to use on narrow work (2 in. or less).

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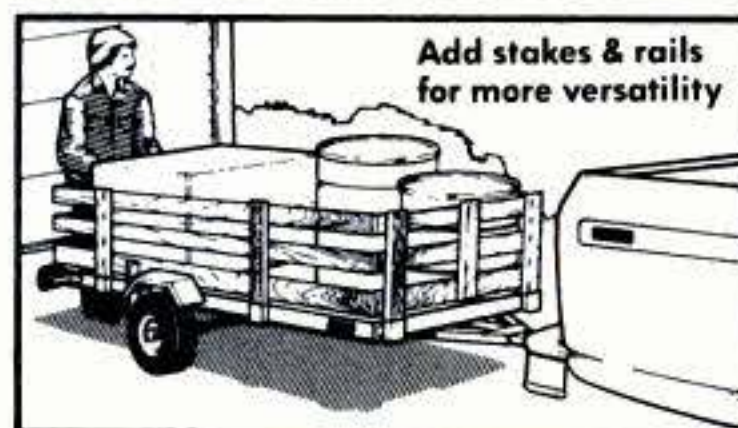
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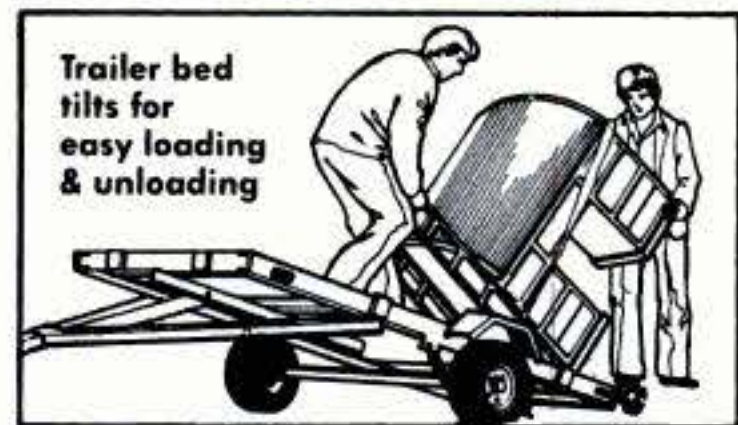
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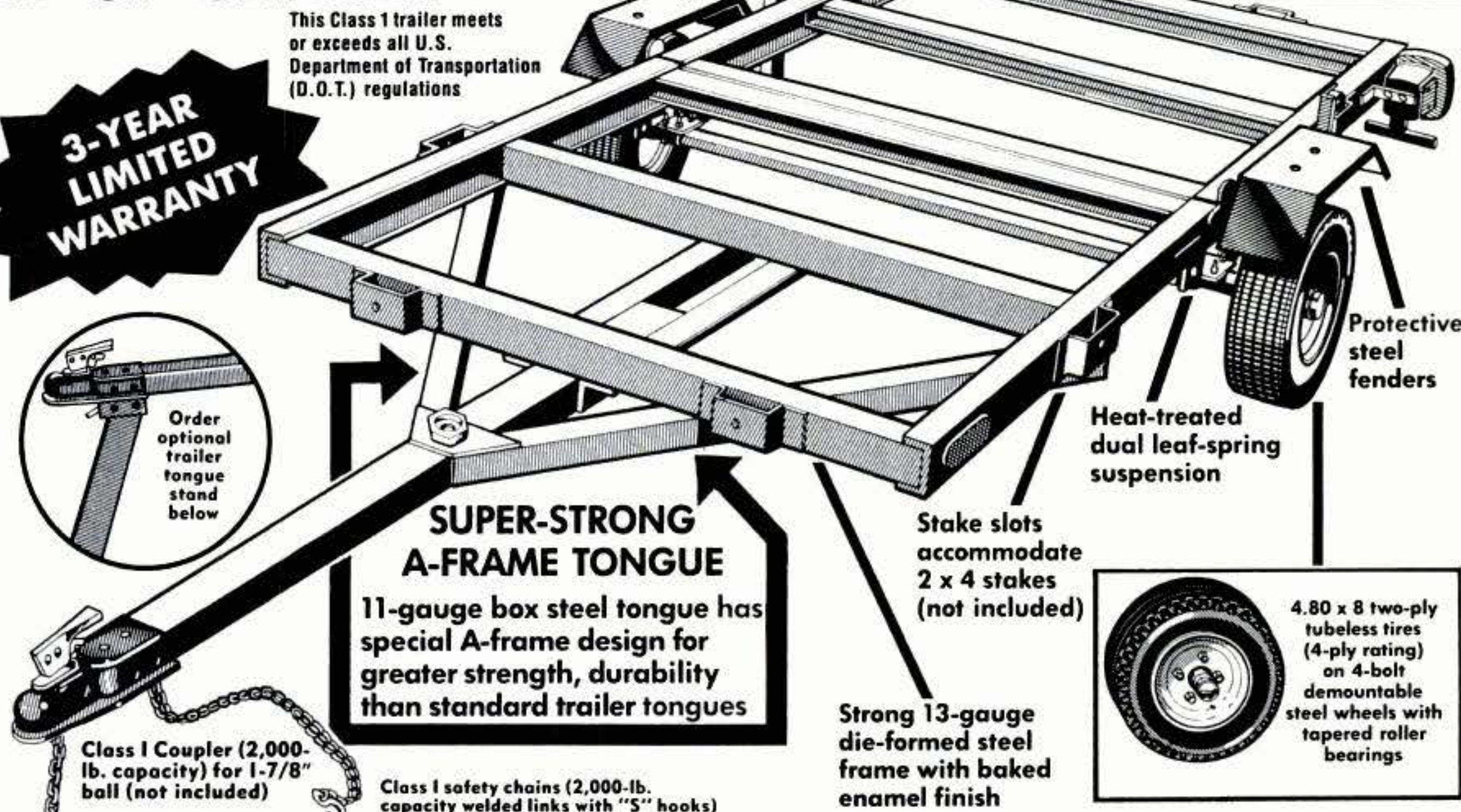
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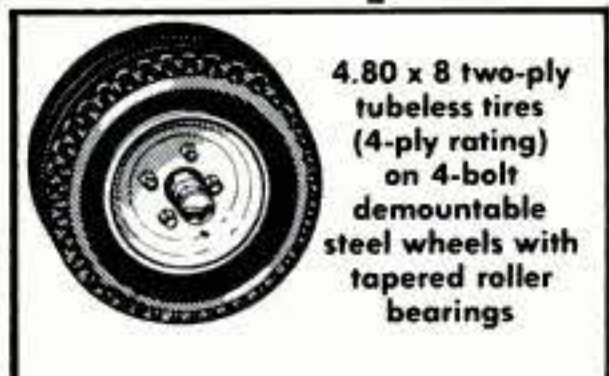
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How to dowel almost anything *Continued*

choose depends on the type and amount of joinery you plan as well as the capabilities of the jig.

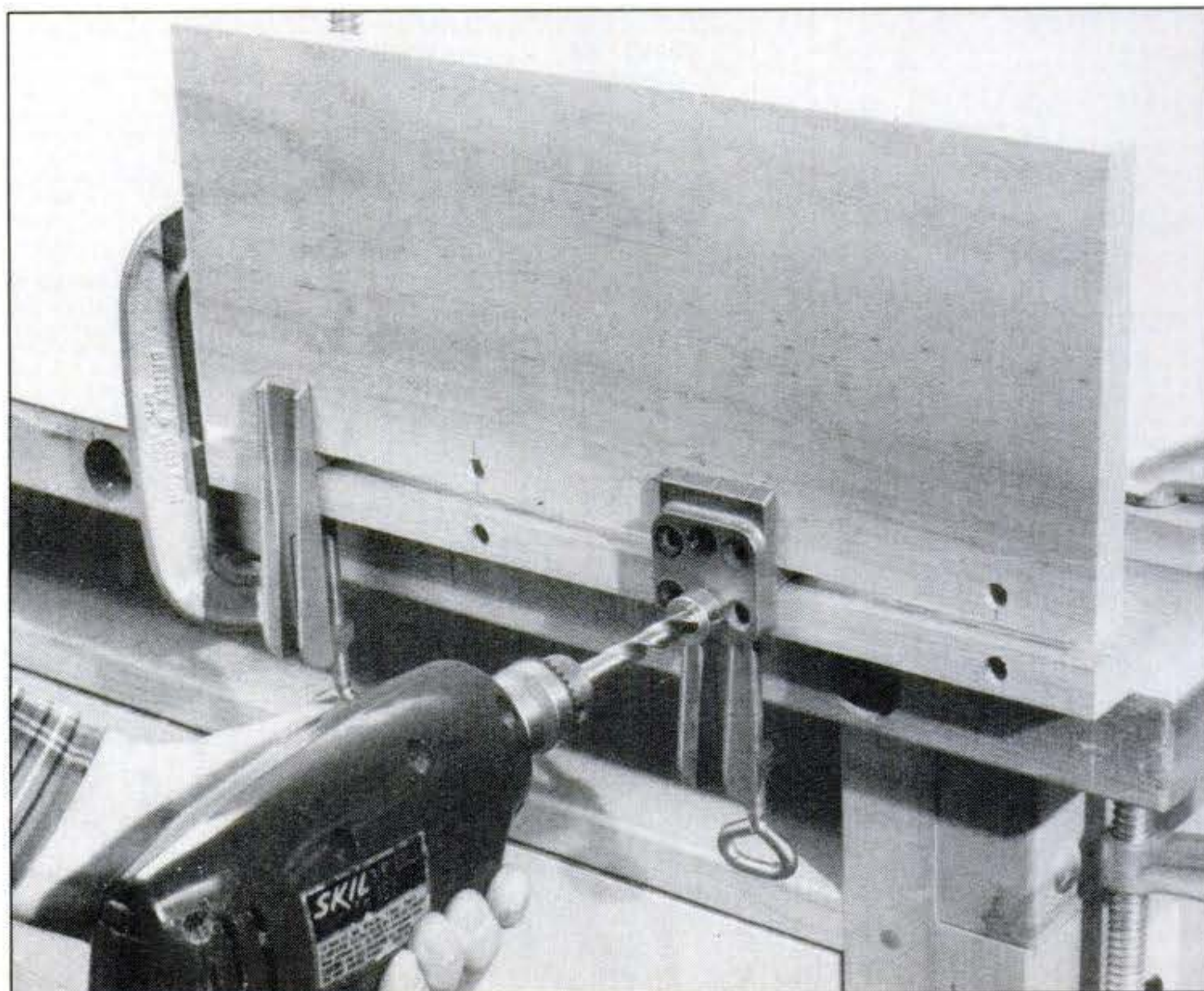
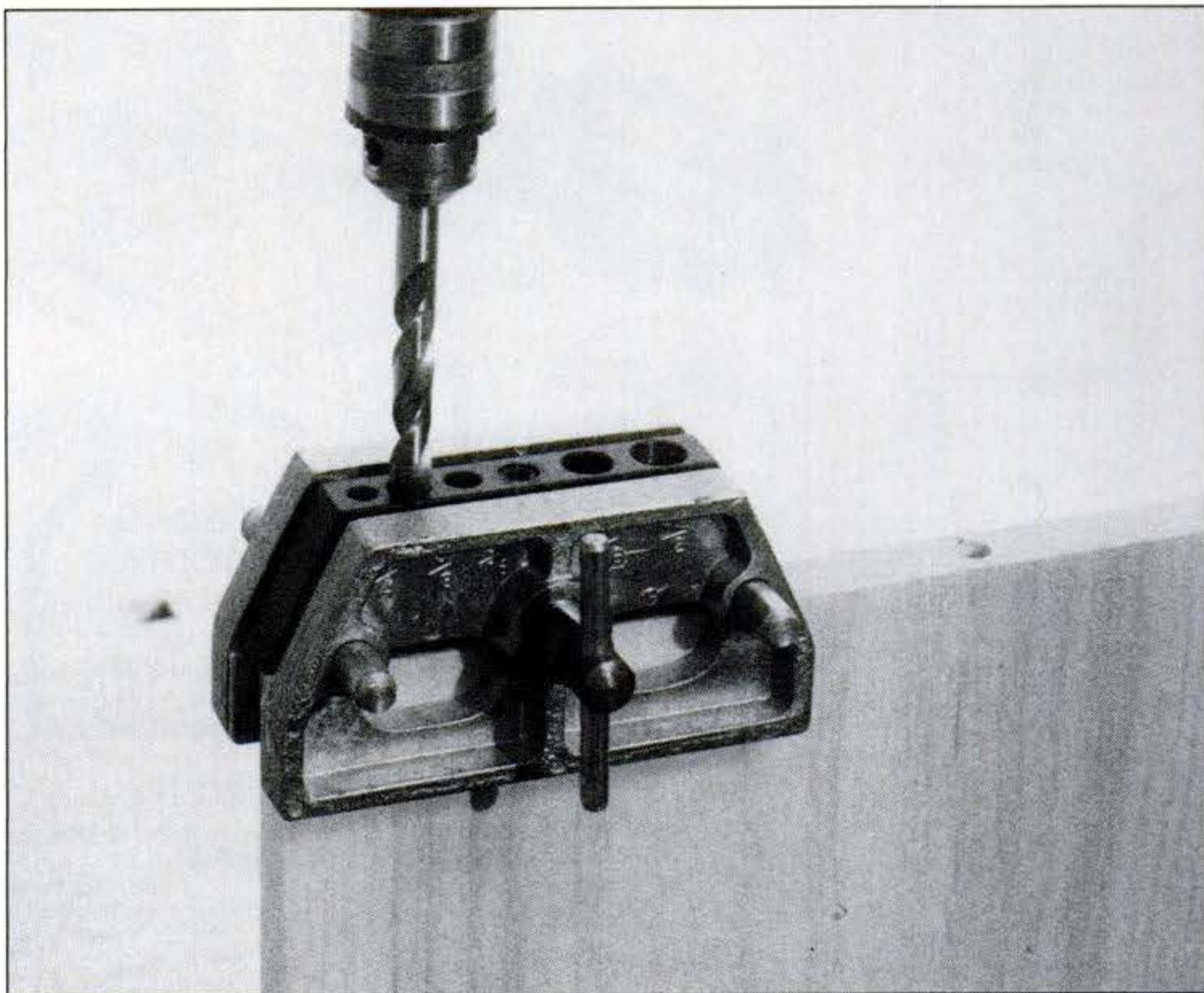
If you anticipate doing a lot of varied doweling, I recommend the Record 148. It is highly versatile and will handle anything.

If you only dowel occasionally, buy a set of dowel centers, or dowel centers and a jig such as the Stanley 59. Use the centers to transfer hole locations; use the jig to get your drill positioned and hold it perpendicular while you drill the hole.

I think the Stanley jig is also the

best choice for board edge-to-edge, frame edge-to-end, and post-to-rail joinery. For board-edge-to-board-side corner joints, I'd choose the Disston 5243. If you can't find doweling jigs locally, you can order them from the mail-order sources listed at the end of the text. (Check their catalogs to see which jigs each offers.)

There is still a place in the shop for homemade doweling jigs, though not as much as years ago. Back when dowel holes were usually drilled with a hand-powered auger bit in a brace, a home-built wood jig would last a



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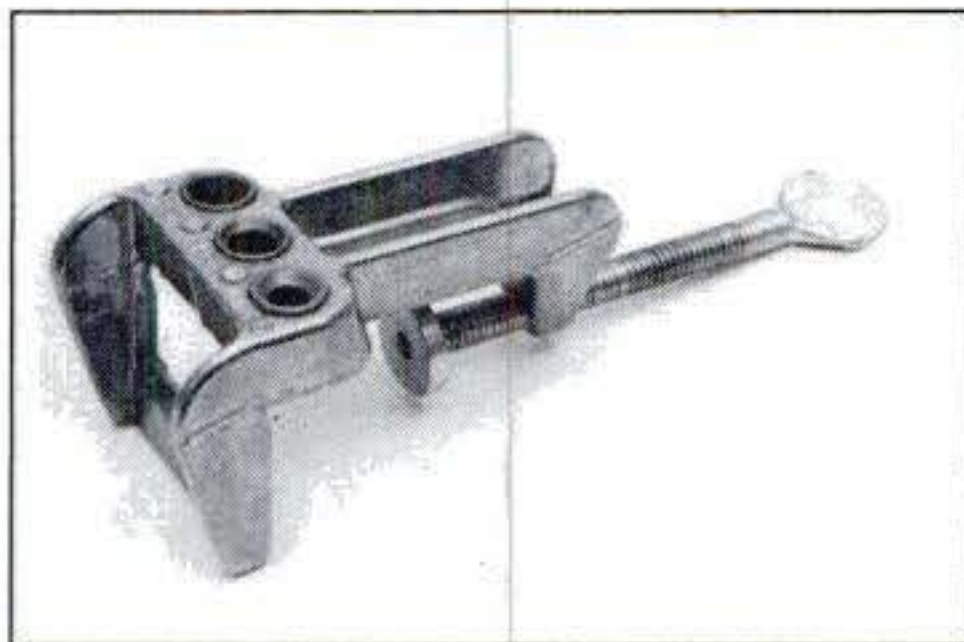
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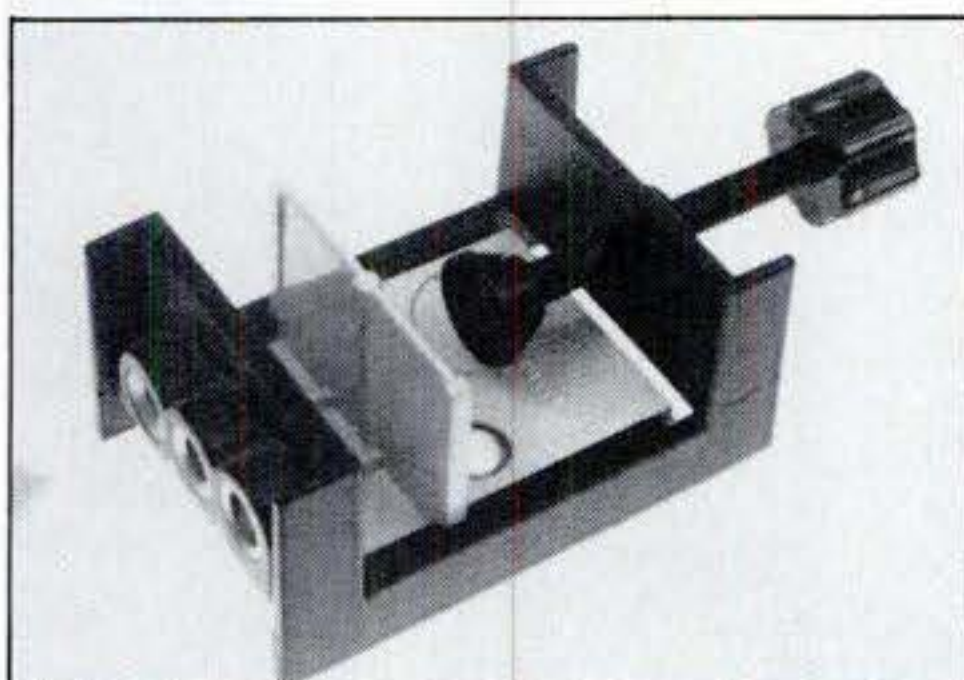
long time. I made one jig for drilling holes for adjustable shelf brackets and used it for project after project.

But once I started drilling holes with an electric drill, I was lucky if the jig lasted one job. A powered bit tends to chew up the jig and destroy accuracy. So I returned to laying out the holes on each piece, using one of the more-durable, if general-purpose, commercially made jigs.

The main shop-made jig you'll find useful today is the one-shot jig you'll have to discard after use. I find such
Continued

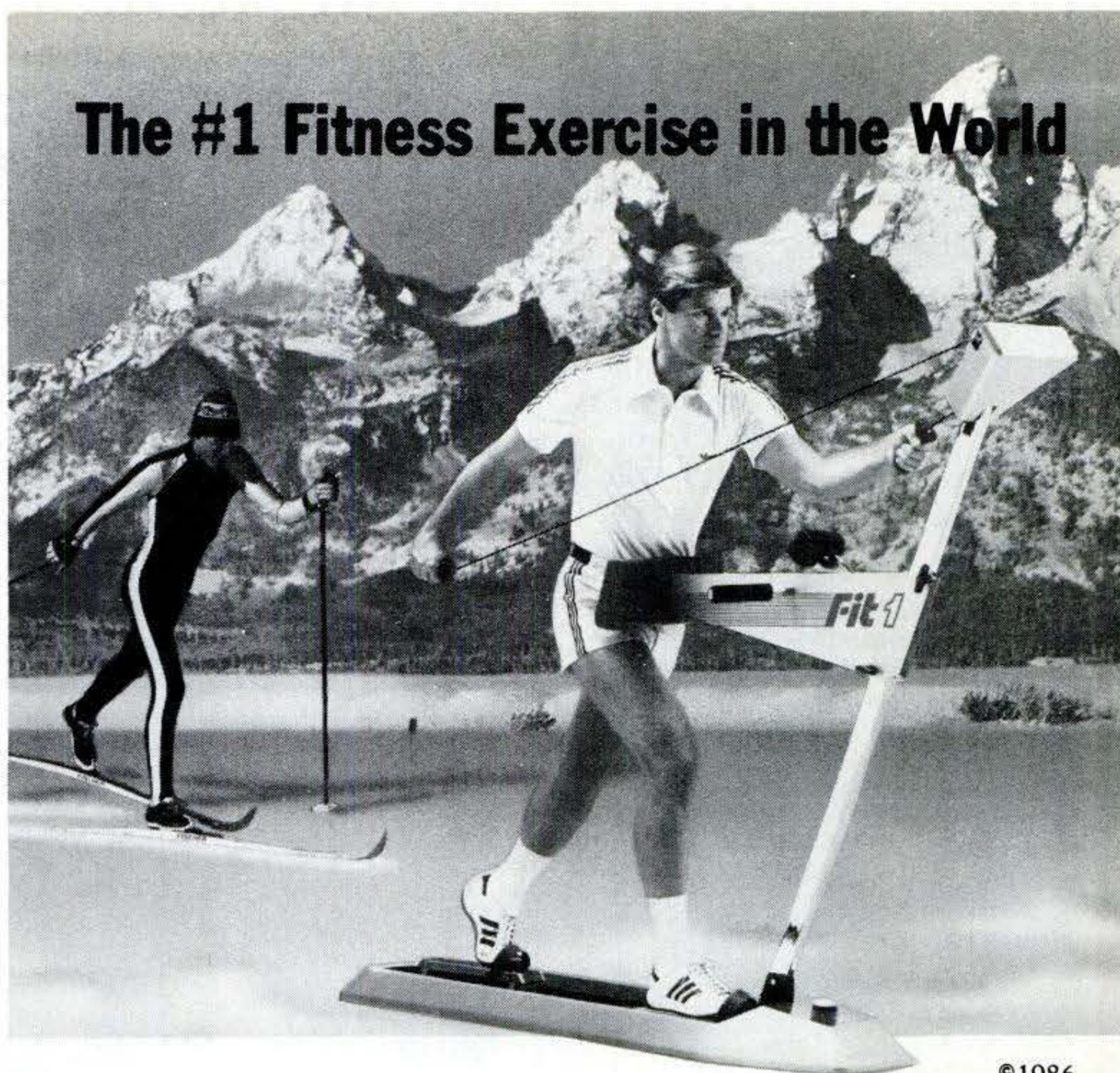


Deep drill-guide holes in the Dowl-It 1000 jig (left) keep the drill perpendicular; use a drill stop to control hole depth. This jig positions holes along the center line of stock by aligning index marks with your pencil marks. But the index marks are difficult to see, so mating dowel holes can only be as accurate as your alignment of the jig to your pencil line. The jig can be tightly clamped without marring the wood surface, so it's good for boring holes in ends of cupped boards as shown. Like the Dowl-It, the Vermont American 7910 jig (above) will handle stock up to 2 in. thick. But the jig will only locate holes near one edge of the stock.



The Disston 5243 doweling jig simultaneously locates mating holes in both pieces for edge-to-side corner joints (left). The jig and a matching accessory clamp hold pieces for simultaneous alignment and drilling of mating holes. For edge-to-side corner joint, boards are clamped in the jig and accessory clamp and clamped to the bench. Clamp and jig are moved one at a time to new positions. The easy-to-use set locates accurate mating holes.

Like the Disston jig, the Leichtung 6742 dowel jig (above) simultaneously locates mating holes. But it's not as easy to operate as the Disston because it has T-spacers instead of a clamp.



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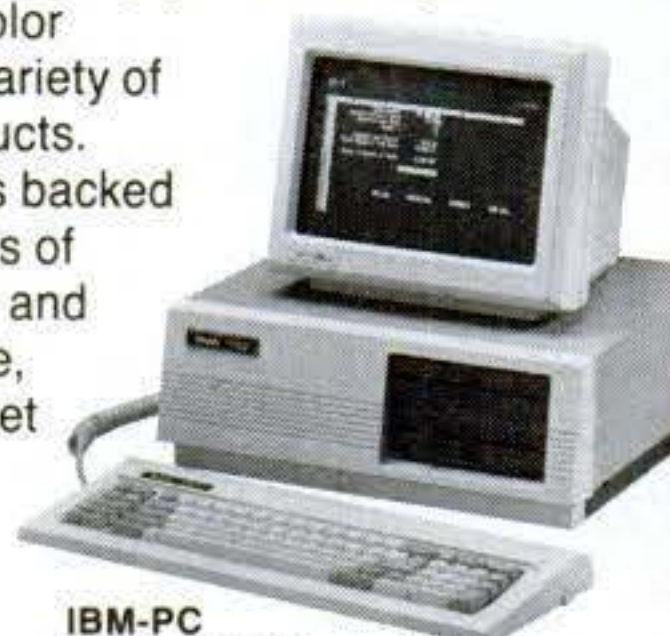
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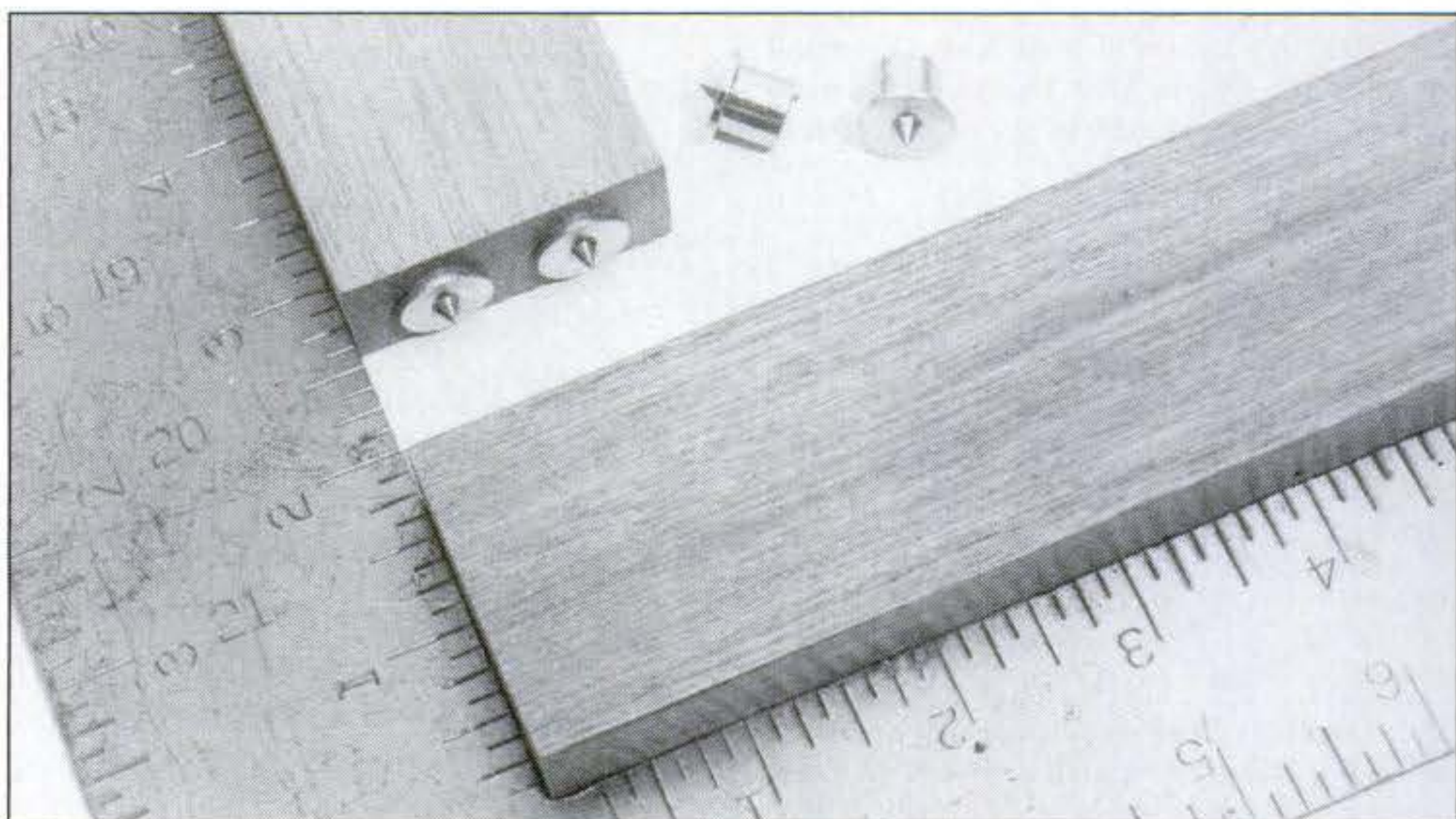
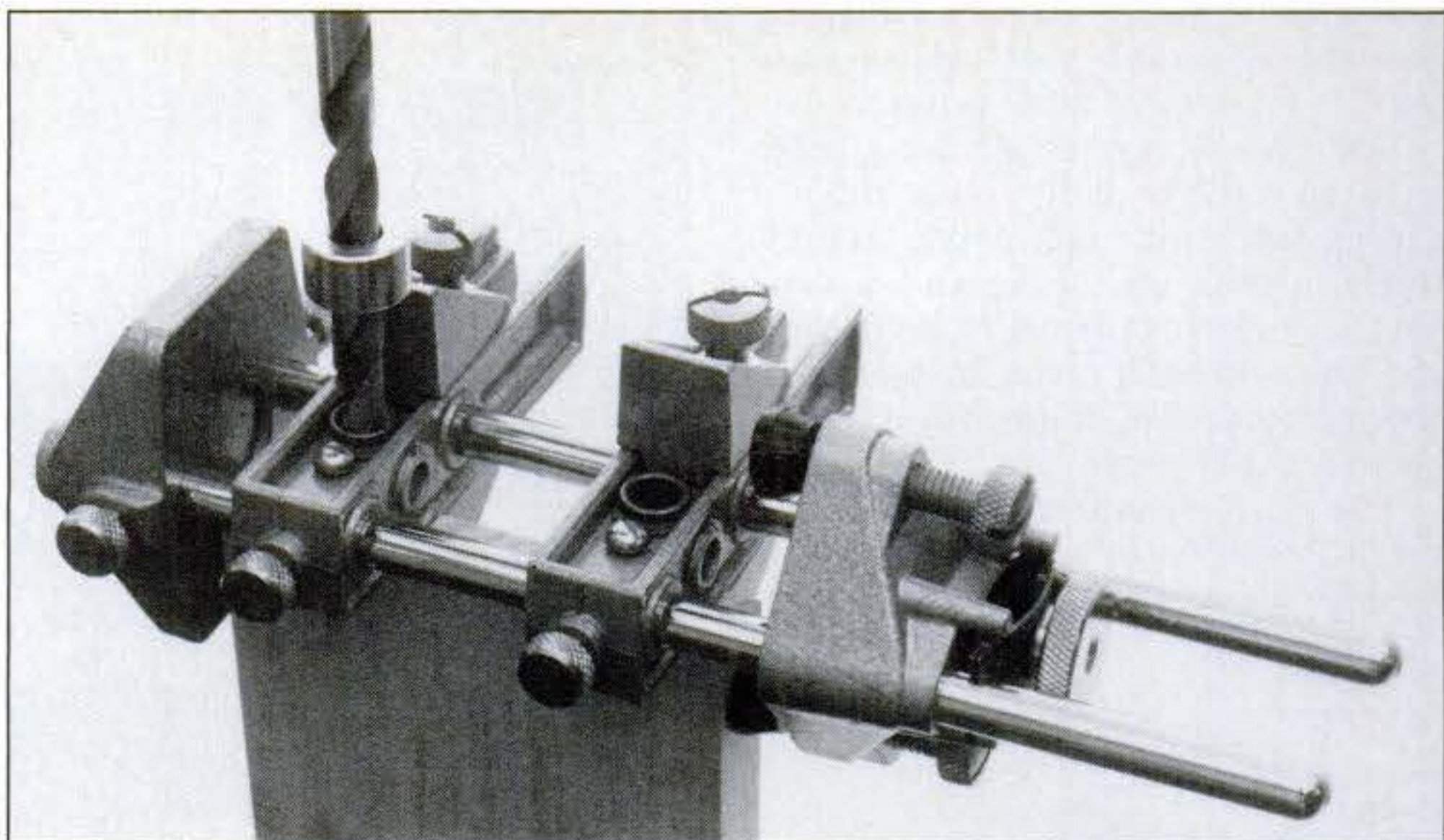
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How to dowel almost anything *Continued*



jigs especially useful when I'm making recessed post-and-rail (or leg-and-apron) joinery. With these joints, there's no place to hide or correct minor hole-locating errors you might make. So even if the jig lasts only for the one job, it's worth it to produce a neat, precisely aligned joint.

There is one secret for making a successful and accurate dowel jig: Design the jig so you drill through it in one direction for the first set of holes

and in the other direction for the mating holes. This way, minor errors in hole location are self-correcting, and the only real accuracy requirement is that the holes be drilled perpendicular to the face of the jig.

If you want to make your own dowel pegs, use birch dowel sticks, but buy carefully. Use calipers to check diameters—they may differ from end to end, and some sticks may not even be round.

Record 148 doweling jig handles just about any doweling joint efficiently. To make a carcass corner joint, the jig is first clamped across the side of the workpiece. Fences are set against the end of the board, and holes are drilled in the side. Without changing the jig adjustments, it's moved to the second workpiece (left) to drill mating holes in board end. Fences are now set against side of board. The jig comes with two bushing carriers; additional carriers can be obtained so you can drill as many holes as you want in one shot. As supplied, it will accommodate boards up to 6 in. wide. Rods are available for 12- and 18-in. capacity, but you can get 4-ft. capacity with $\frac{3}{8}$ -in. cold-rolled steel rods. The jig also works for miter-joint doweling.

Screw-in bushings on the Dowl-It 2000 (left) let you simultaneously align two adjacent dowel holes on the workpiece. This jig is primarily intended for framing and board-edge doweling, and the bushings are drilled for $\frac{1}{4}$ -, $\frac{5}{16}$ -, and $\frac{3}{8}$ -in. bits. Like the Dowl-It 1000, the jig has deep drill-guide holes that prevent the drill from wandering from the vertical. And the jig can be tightly clamped to the work without much chance of marring the surface. Setup is more difficult than with other jigs. Hole positions along the center line are located by aligning index marks with pencil marks or by sighting through the drill hole. It is hard to see the jig's index marks; sighting through the dark drill hole is also difficult.

Dowel centers are the simplest and least-expensive type of doweling jig. Inserted into holes drilled in the first workpiece (left), the pointed dowel centers mark where to drill mating holes in a second workpiece pressed against the first. Dowel centers can be bought in sets of different sizes (you will need at least two of each size to use them effectively), or you can buy them by the dozen in a single size.

When using dowel centers, drill the holes in end grain first. If a drill is going to wander, it's more likely to do so in end grain than in side grain. Use clamped scrape fences or a square as shown to accurately align workpieces. Then press them together to mark the centers where you'll drill mating holes.

Cut dowels to length and chamfer the ends. You don't have to roughen the dowel to get today's glues to stick, but saw a kerf down one side so excess glue can escape. **P.S.**

WHERE TO GET DOWELING JIGS

Constantine, 2050 Eastchester Rd., Bronx NY 10461; Craftsman Wood Service Co., 1735 W. Cortland Ct., Addison IL 60101; The Fine Tool Shops, 20 Backus Ave., Danbury CT 06810; Leichtung, 4944 Commerce Pkwy., Cleveland OH 44128; U.S. General Supply, 100 Commercial St., Plainview NY 11803; Woodcraft Supply Corp., Box 4000, Woburn MA 01888; The Woodworkers' Store, 21801 Industrial Blvd., Rogers MN 55374

Turn page for more on dowel jigs

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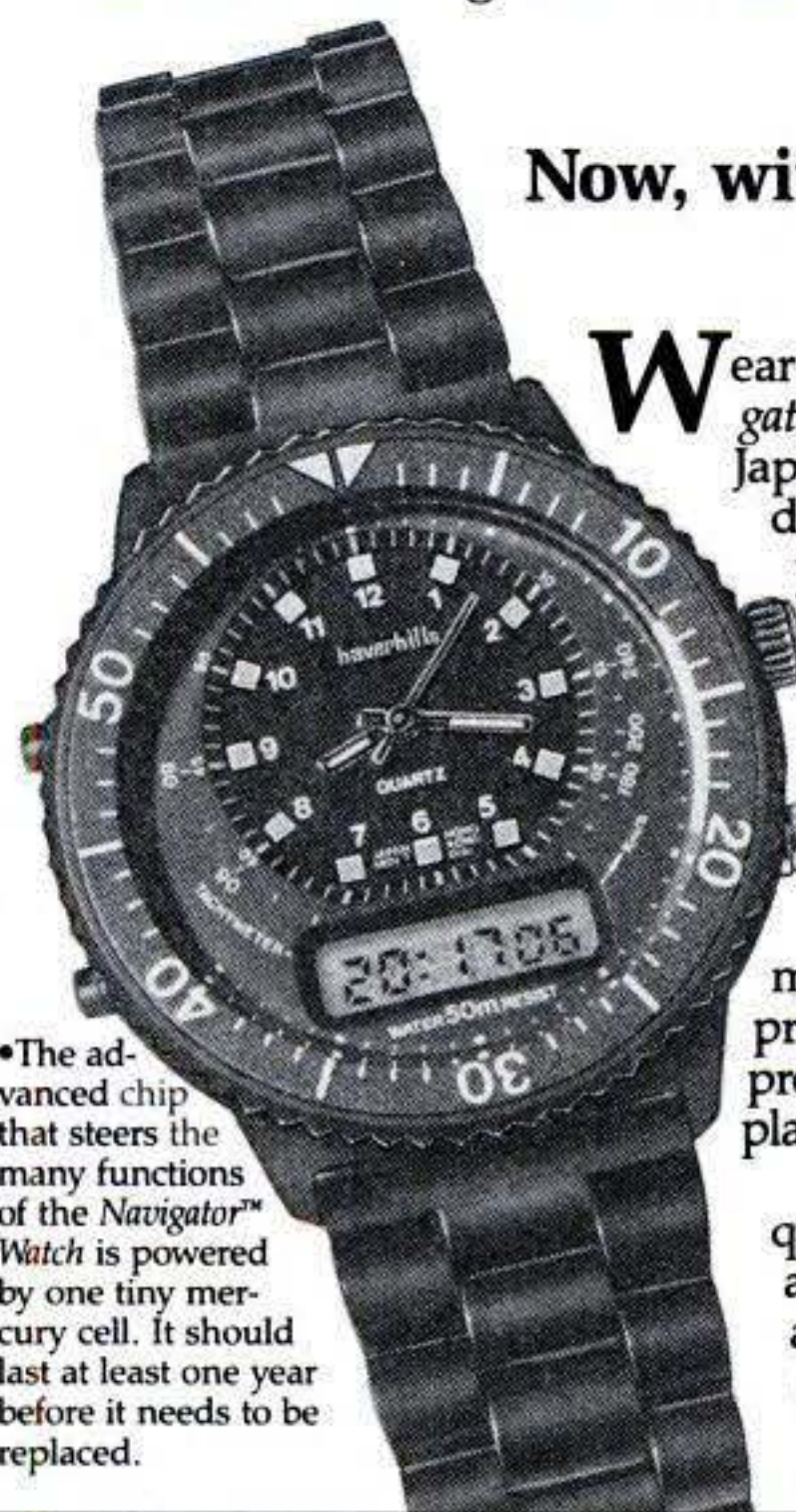
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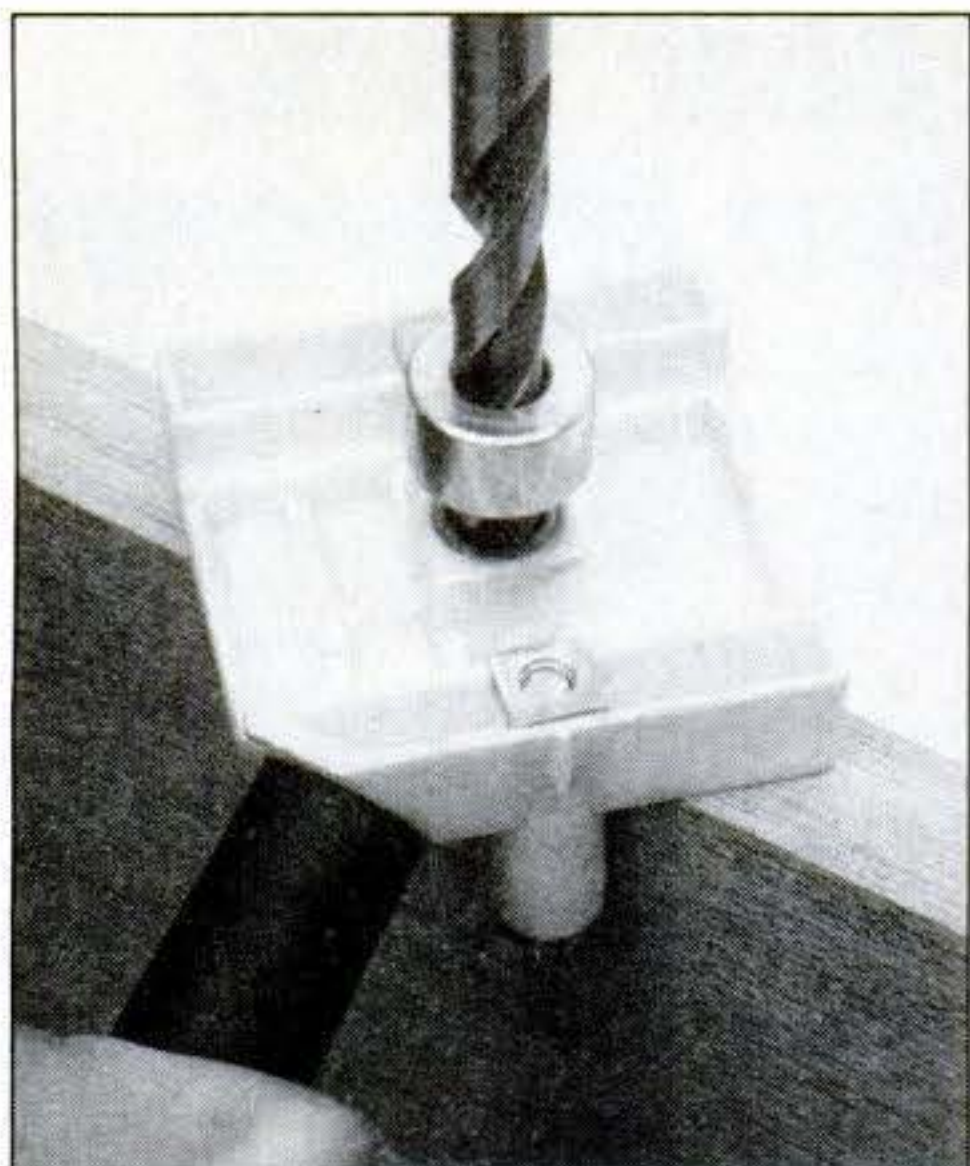
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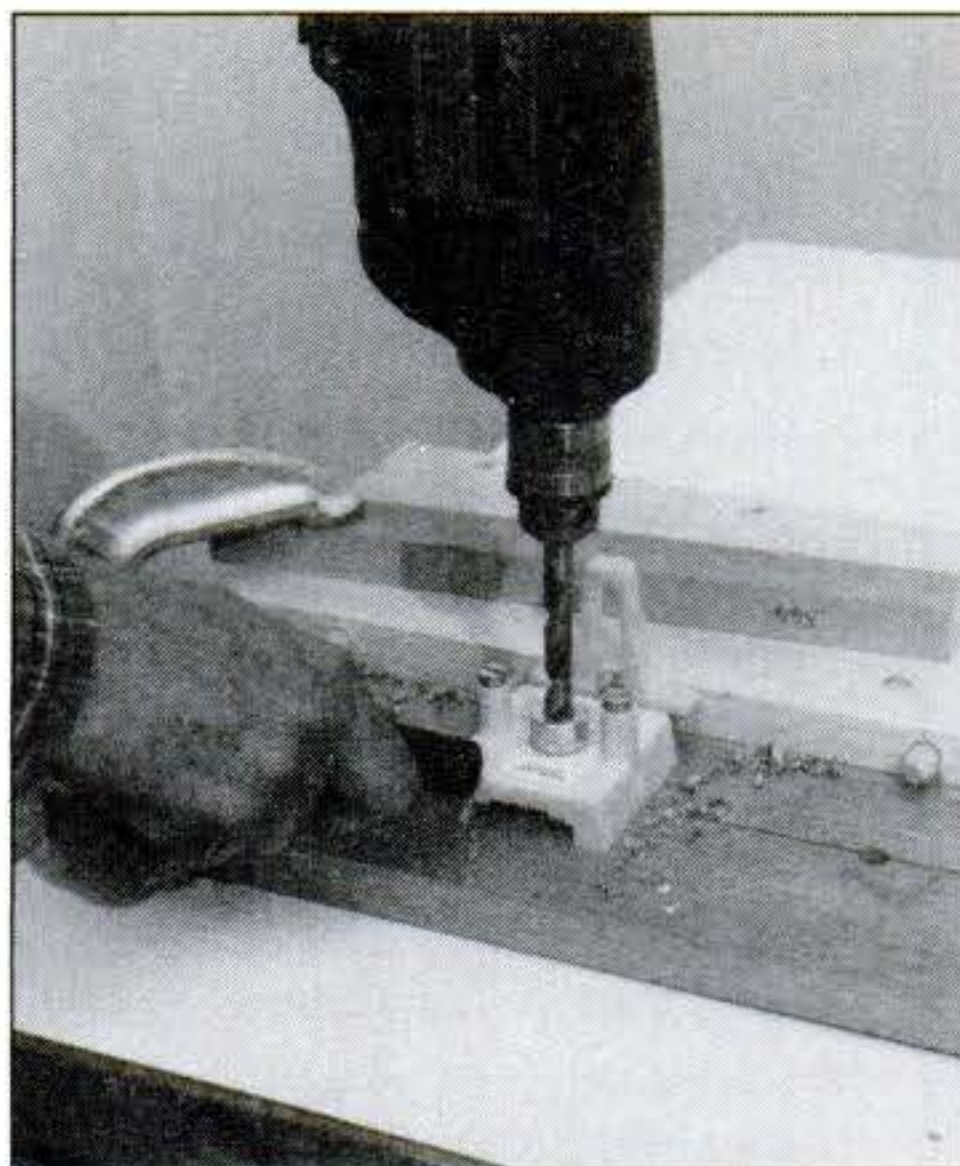
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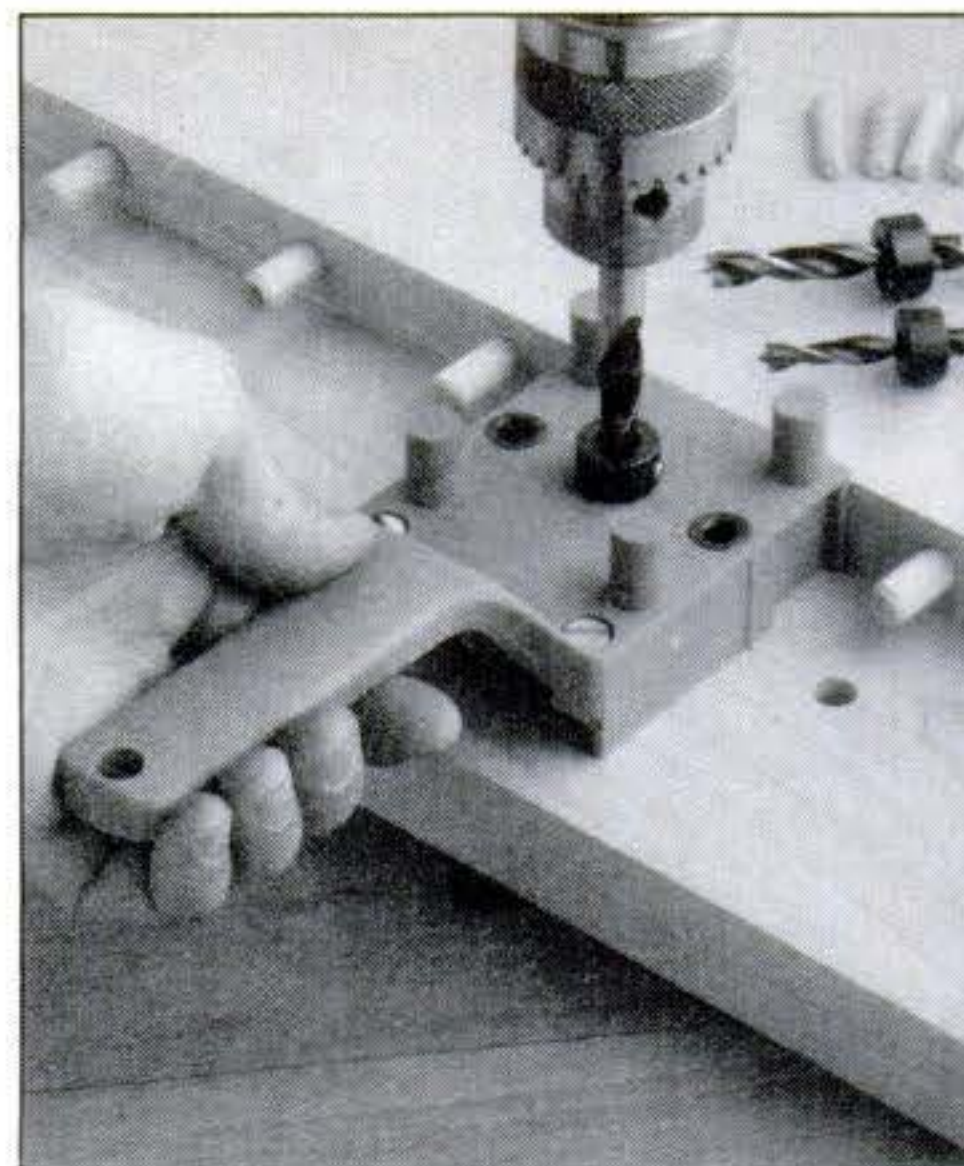


Both the Disston Dowel Magic Jig (above) and Wolfcraft Dowelmaster (above, far right) are hand-held against the work edge by the clamping action of protruding posts. You visually align the jig by sighting a pencil mark through the drill bushing. But accuracy



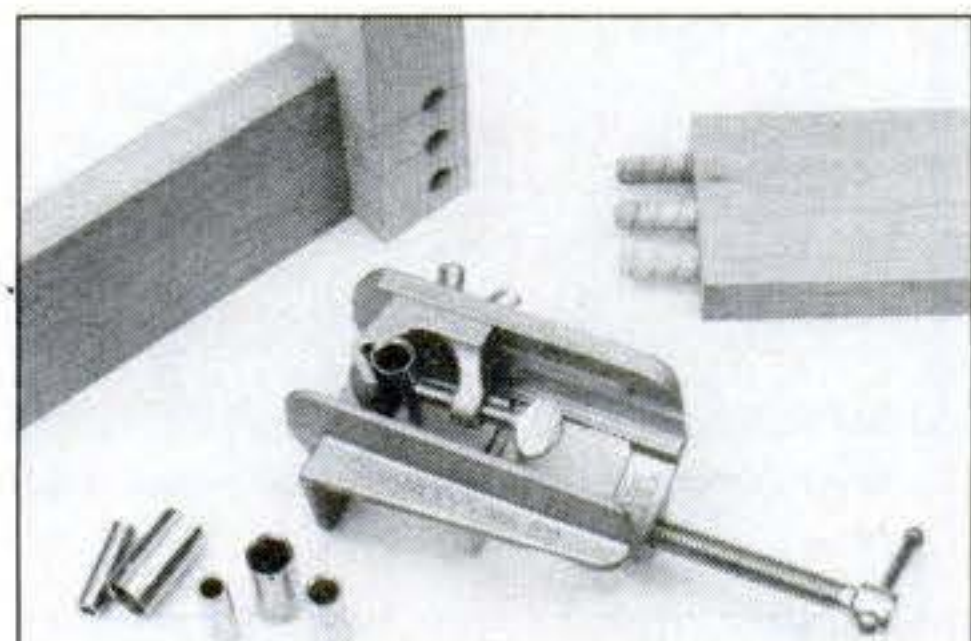
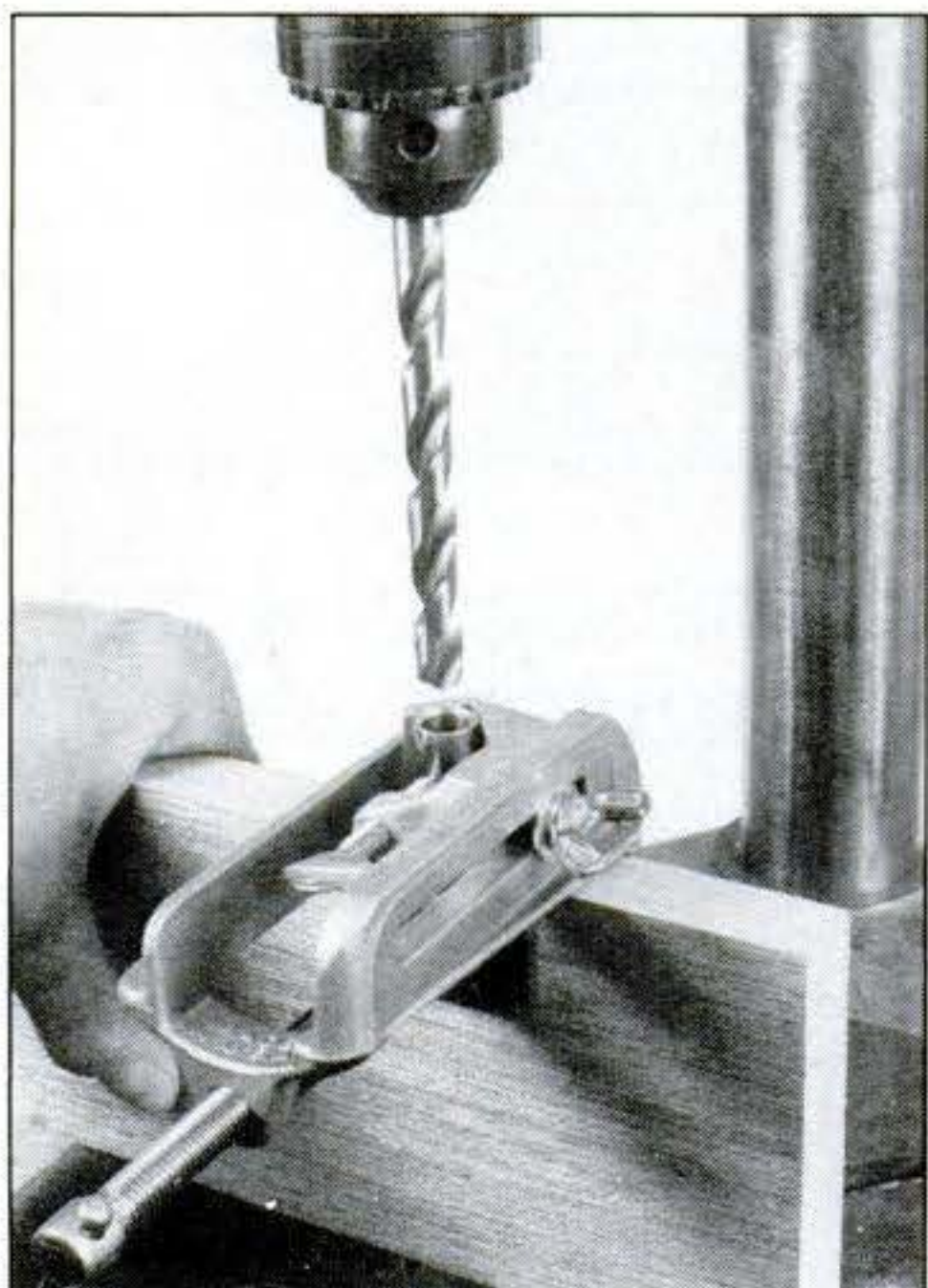
depends on your ability to hold the tool flat against the workpiece.

To align the jigs for drilling mating holes, dowels are inserted in the drilled holes, and the second workpiece is aligned and clamped under the drilled workpiece (above center). An adjusta-

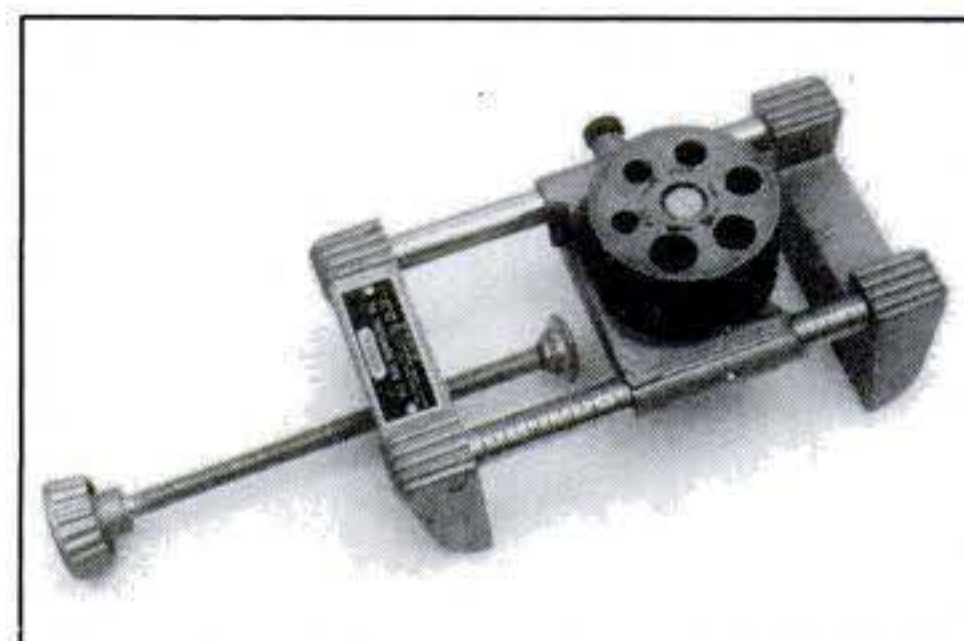


ble guide fits over the dowel to aid alignment. But the slot in the Disston unit tested was $\frac{1}{32}$ in. oversize on the $\frac{3}{8}$ -in. jig—enough to cause problems.

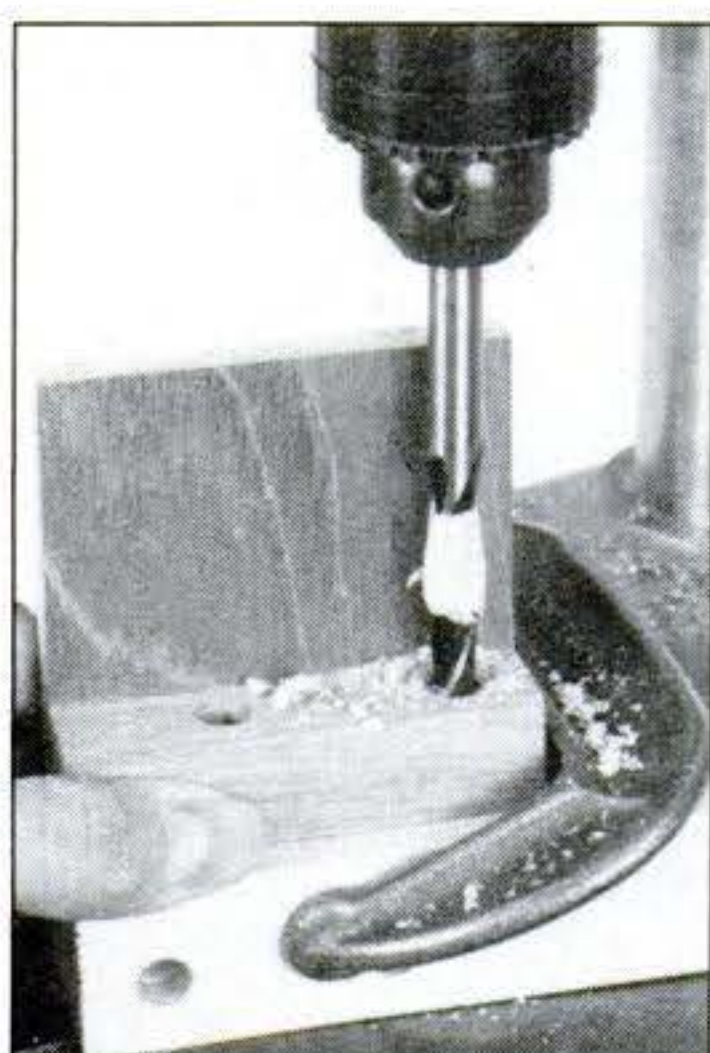
The Wolfcraft jig can be used for drilling off-center-line holes in posts, a job I wouldn't try with the Dowel Magic.



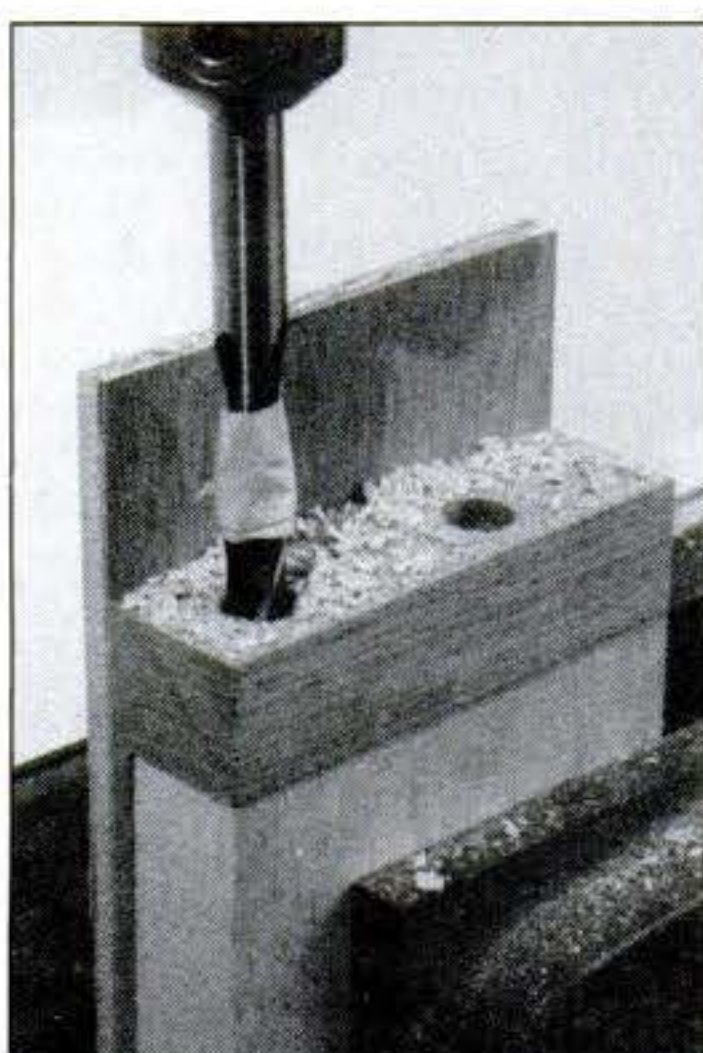
The versatile Stanley 59 jig can locate holes anywhere on the workpiece surface. It's ideal for making post-to-frame joints where dowel holes are not all on workpiece center lines (above). The well-made jig has a calibrated scale for hole location, making it easy to position and drill multiple holes across work at one jig location. Removable drill bushings can be raised for mark visibility, then lowered for drill guidance without changing the setting.



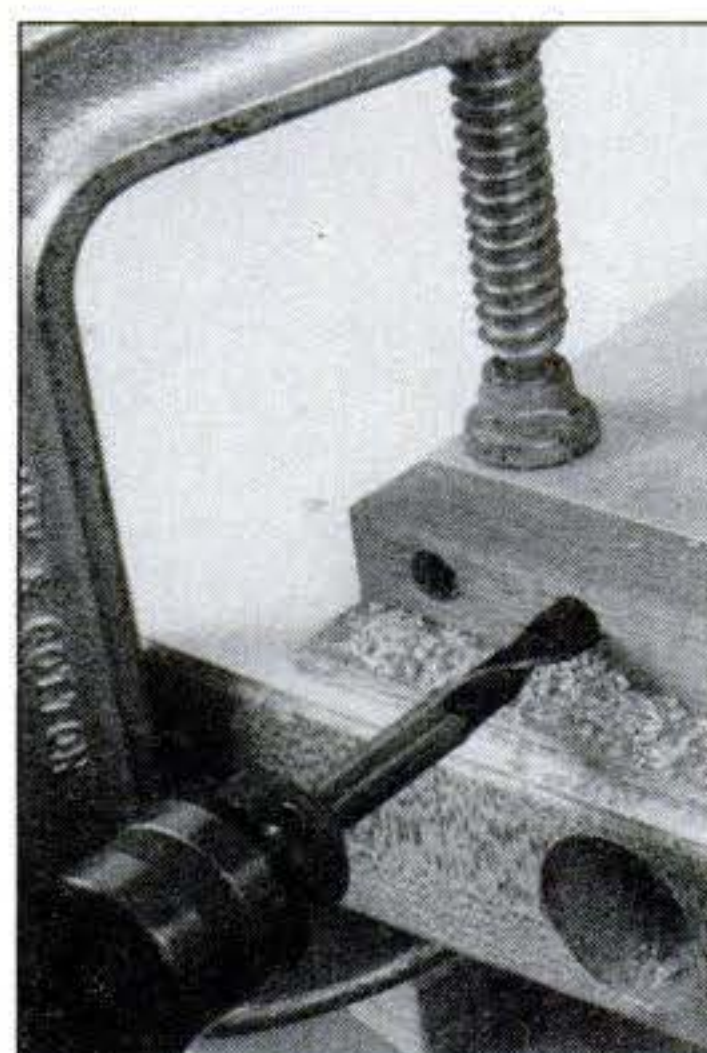
Using the Stanley jig with a drill press (left) to ensure that holes are perpendicular to the joint-mating surface is an almost-foolproof way to produce accurate dowel holes. Like the Stanley, the U.S. General 840 doweling jig (above right) can locate holes anywhere on surface of work relative to the edge. The well-made jig has a calibrated scale for hole location; multiple holes can be accurately positioned and drilled across work at one jig location.



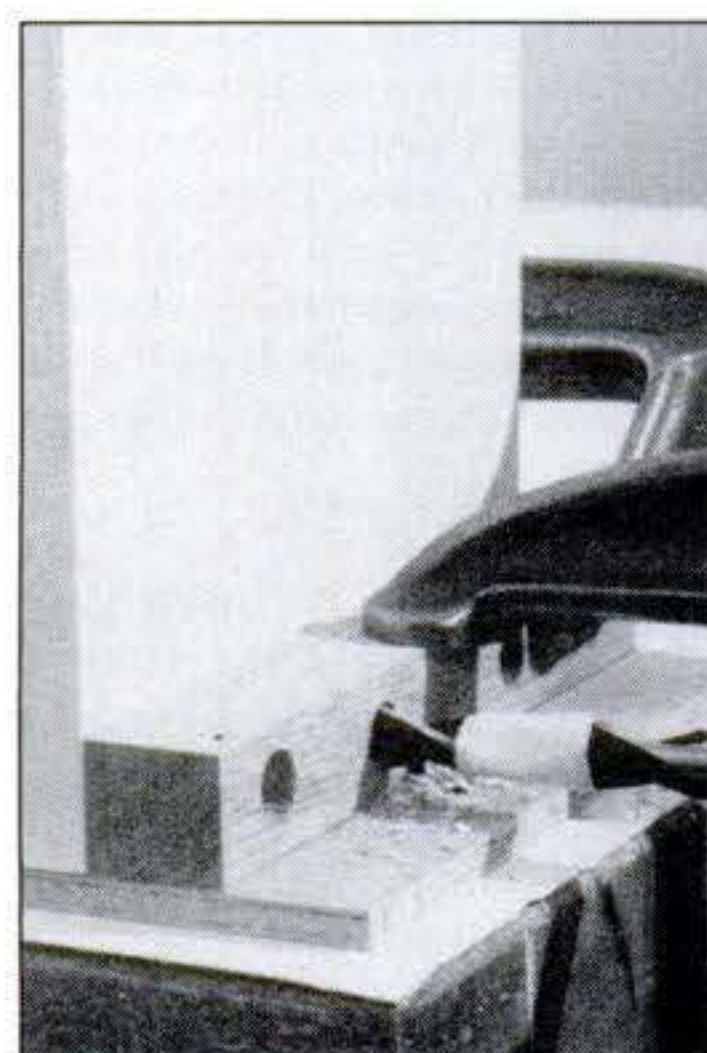
For difficult jobs, shop-made jigs can ensure accuracy. A homemade jig for making recessed post-to-rail joints has dowel-hole locations offset to avoid in-



terference inside the post. The jig is first used for drilling holes in the post (far left) and then for drilling holes in the rail (left). To make carcass corner



joints, a shop-made jig is used for drilling holes in the end of workpiece (right) and drilling mating holes in the side of second piece (far right).



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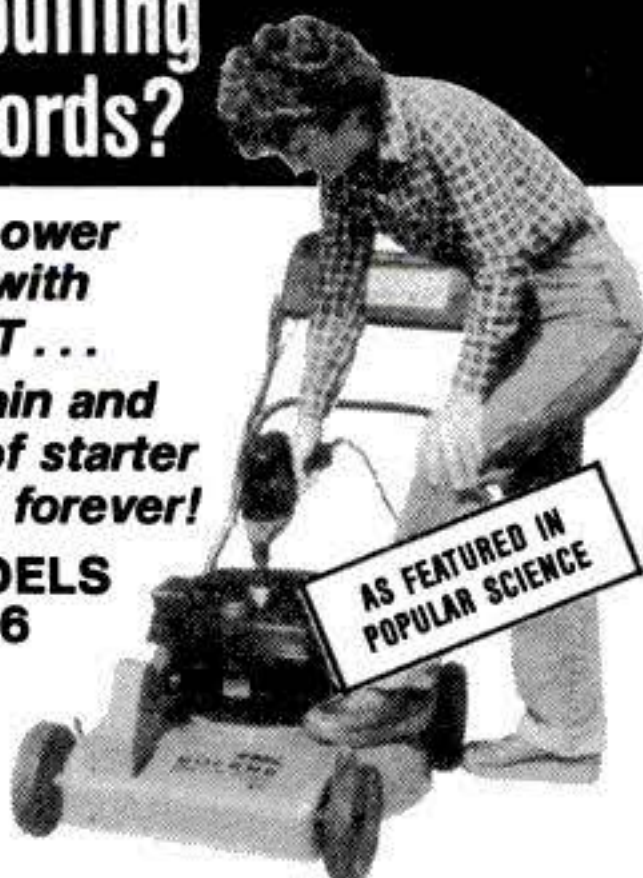
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Chunnel for the channel

[Continued from page 84]

finish, said project engineers I talked with. The trick is to lay out survey lines across the channel above ground, then use these to align lasers that help steer the drilling machines.

Because a laser beam is perfectly straight and spreads very little over many miles, it has become a useful tool for guiding tunnel-drilling machines. Normally, the drill operator watches where a laser beam falls in front of the tunneling machine after it passes through a set of cross hairs in the rear. The operator keeps the beam centered by adjusting support legs as drilling progresses.

But clouds of dust and strong vibrations make this centering job tough. So automatic-steering systems have been developed in which the guiding laser beam hits a light-sensitive panel of photodiodes. A microcomputer in the system then calculates the machine's position to within a few inches and makes necessary corrections. "With lasers," says John Taberner, engineering director of the British tunnel group, "you can have a tolerance of, say, two centimeters whether you're going one mile or ten miles."

Tunnels for cars?

One unresolved problem of the project involves drive-through automobile tunnels. The current plans don't call for any; all vehicles travel on special shuttle trains. But the agreement between the British and French governments says that the tunnel group must build a car tunnel before the year 2000 or lose its monopoly.

Whether that can be done is uncertain. The tunnel group studied a drive-through tunnel and concluded that—at least for now—it isn't feasible. There are two reasons. First: "A road tunnel with sufficient safety for two lanes must be in excess of thirty-three feet in diameter," says Kirkland. But the chalk tunneling layer thins near the center and the French side, so tunnel walls may not have enough structural support overhead, or be too close to the soft clay layer below.

Second, technology can't yet overcome the smog caused by vehicles moving at slow speeds for safety. "You would have to have massive injections of air into the tunnel that would result in winds of some seventy miles per hour," explains Gordon.

Still, the tunnel group plans to probe the thickness of the chalk layer as the Chunnel is built to see whether it could support 33-foot car tunnels. "We could also pretreat the ground as we go through this time," says Taberner. "Then the decision to build a road tunnel could be made later on the basis of available traffic."

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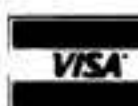
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Word machines

[Continued from page 94]

On typewriter models with a Spell-Right feature, the "code" and D keys activate the typewriter's dictionary (35,000 or 50,000 words with a 300-word customized dictionary, depending on the model). Now as you type, the clever system looks over your shoulder: Type a word (or even part of a word) that's not in its dictionary, and you are signaled with a beep.

The PWP works well—like a smart typewriter with a large screen—but because it uses a standard keyboard, the true editing features of the word processor must be done at the out-board key pad.

To delete a block of text, you use the key pad's cursor and "marker" buttons to highlight the text. Then, returning to the typewriter's keyboard, press the "correct" key. It's simple and fast once you're used to it, but it was awkward for me. It seemed my hands were always in motion whenever I wanted to search, move, or copy text.

"That's no problem," said PWP user Frimmer, criticizing my key-pad comment when I mentioned it. "You're simply used to a computer."

A computer?

Although Magnavox and Smith Corona are quick to point out that these machines are not computers, both compare favorably with many home computers I've tried. But word machines are inflexible: You can't change the word-processing software for a newer version or do programming or spread-sheet work as you can on a computer. For sheer word-processing power, though, word machines are exceptional devices. Would I choose one over the other?

The Videowriter has more sophisticated word-processing abilities than the PWP. Its help screens, split screen, and clever word-matching spelling checker are impressive. As a replacement for the old Underwood at home, it's an excellent choice.

For more heavy-duty home or office-related work, the Smith Corona has a slight edge. Its editing operations are a bit faster because changes occur only in memory and are not automatically saved as on the Videowriter. The lack of help screens with a dedicated "do" button saves the experienced operator time. Also, for small work such as envelopes, notes, or labels, the PWP can be switched off: For those jobs, you simply use the typewriter.

Could this be a successful new product category? "I'll never go back to a typewriter again," says Frimmer. **P.S.**

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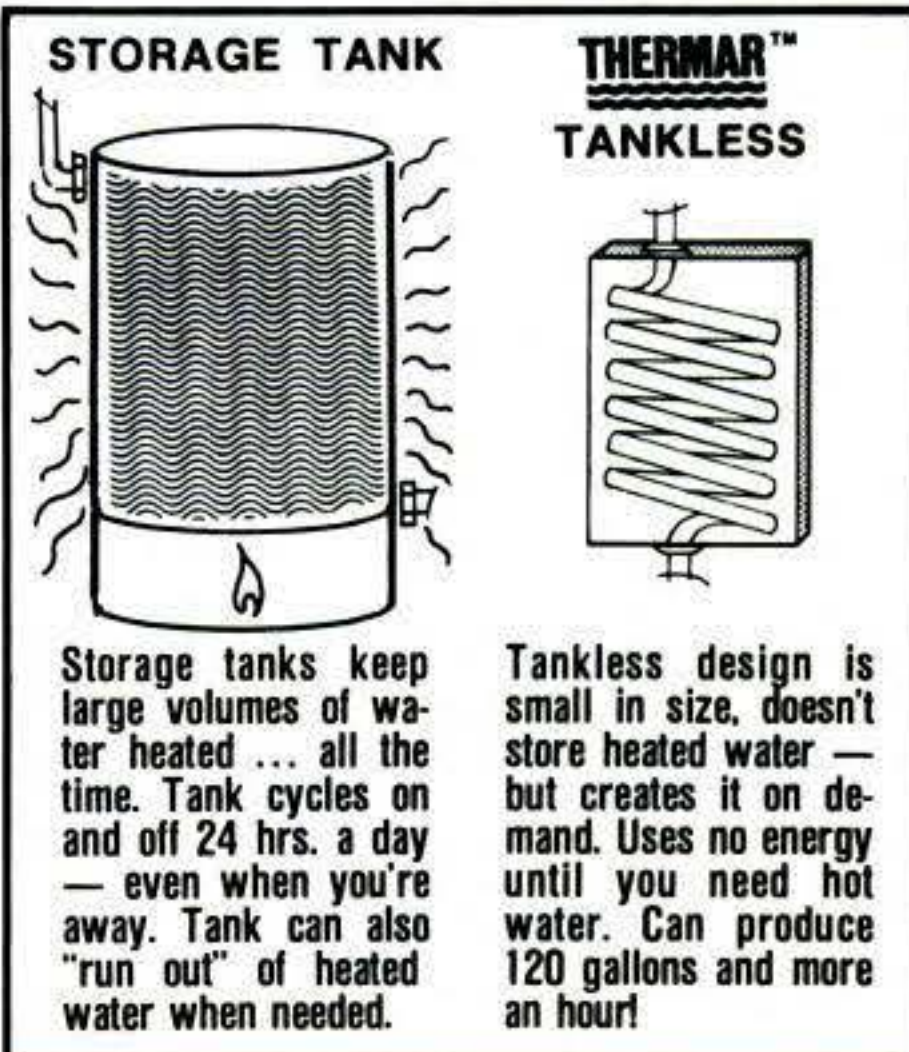
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look promising, then test in wind tunnels. Instead of build and test, build and test, we can converge on a solution much more rapidly."

The final design will be a delicate balance between airframe and engine design. "If the aerodynamicists want to change the spaceplane's body to get better performance, it could degrade the performance of the engine," said NASA's Couch. "There has to be a lot of cross talk here."

Tentative aerospaceplane designs al-

ready exist, prepared by aerospace companies under study contracts performed in recent years for the Air Force (see illustrations). Actual in-flight data are also being analyzed today. The space shuttle *Columbia* carried three experiments directly related to aerospaceplane research during its January mission. Each was activated during its descent from orbit. The shuttle was fitted with a new nose cap containing cruciform orifices to provide continuous pressure readings as it

dropped from space to ground, with an infrared-sensor system to record a complete temperature map of its lee-side body and wing during hypersonic flight and with a mass spectrometer to sample the upper atmosphere. "We need this information to develop a real-time entry air data system that will automatically record the conditions in which a spaceplane or shuttle is flying," Couch told me.

Another "tall pole of technology"—favored Washington jargon for major areas still needing extensive research and development—remains to be climbed. It is developing the lightweight, high-strength materials needed to let an aerospaceplane survive the extreme temperatures and pressures it will encounter.

"Materials research will concentrate on extending the current state of the art on composites like carbon-carbon or carbon connected with something light like beryllium," the White House expert told me. "Those materials are available today as laboratory test pieces, but not in the three-foot sections we need to build a test vehicle."

That means no breakthrough is needed. "We can base our work on existing materials and concentrate on further improvements," Rankine said.

Not too small, but not too big

The development schedule agreed to by the Air Force, Navy, and NASA calls for the current phase to last three years and to include wind-tunnel testing of both scramjet engines and some preliminary airframe designs. If scientists and engineers succeed in climbing those tall poles, the team will ask the Reagan administration and Congress for funds to build a one-of-a-kind research aircraft. It could begin hypersonic flights in the early 1990s.

"The research aircraft has to be large enough to demonstrate the technologies, and small enough so it's not too expensive," Couch said.

Such a craft could be the most exciting X-type machine since the fabled X-15. Its materials, shape, and engines will be the true forerunners of an operational aerospaceplane.

"It's the only way to demonstrate the things you can't do on the ground—propulsion above Mach 7 and behavior of full-size thermal components, systems, and materials," Couch said.

If that phase stays on schedule, plans for an operational aerospaceplane—with the potential for both commercial and military use—could be laid before Congress in 1995.

"What we're talking about here is an airplane," Couch said. "It's just one that flies higher and faster. People can understand the benefits of that." **PS**

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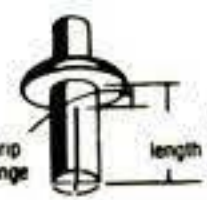
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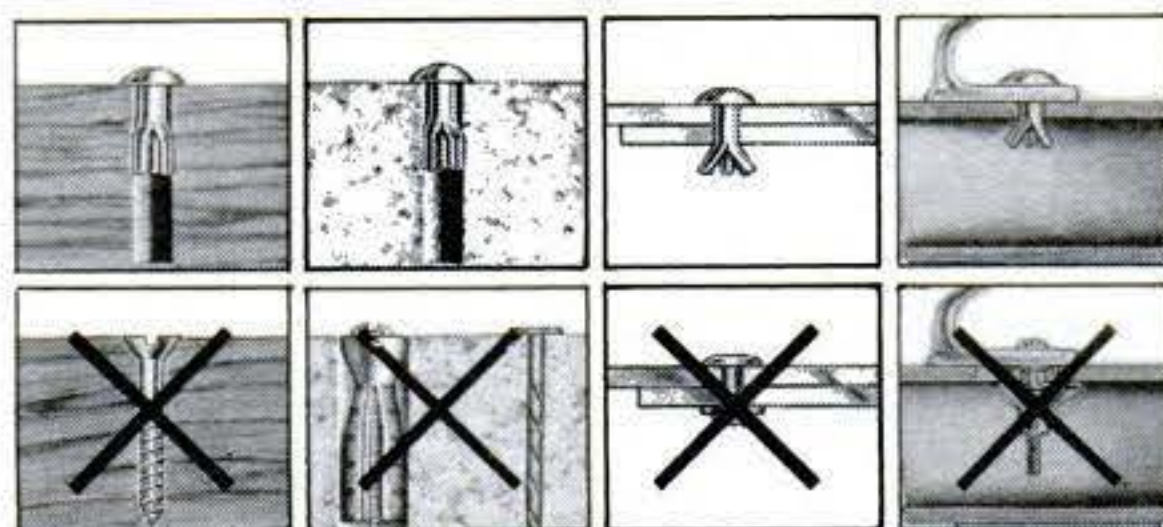
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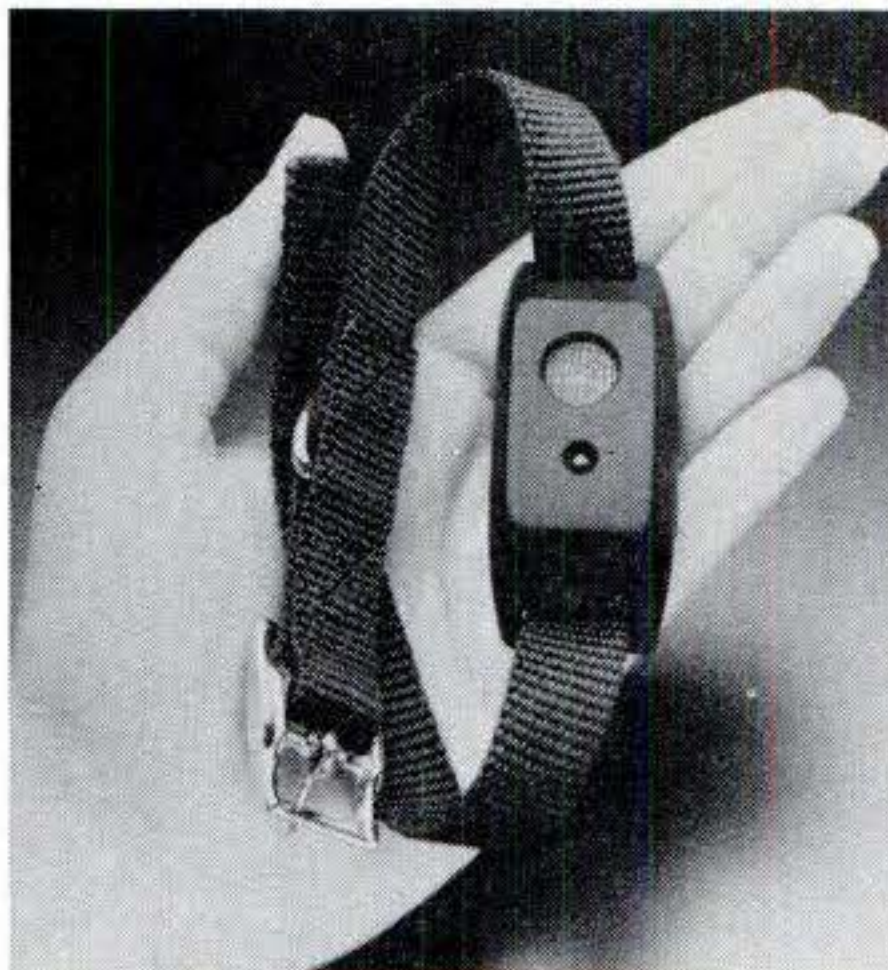
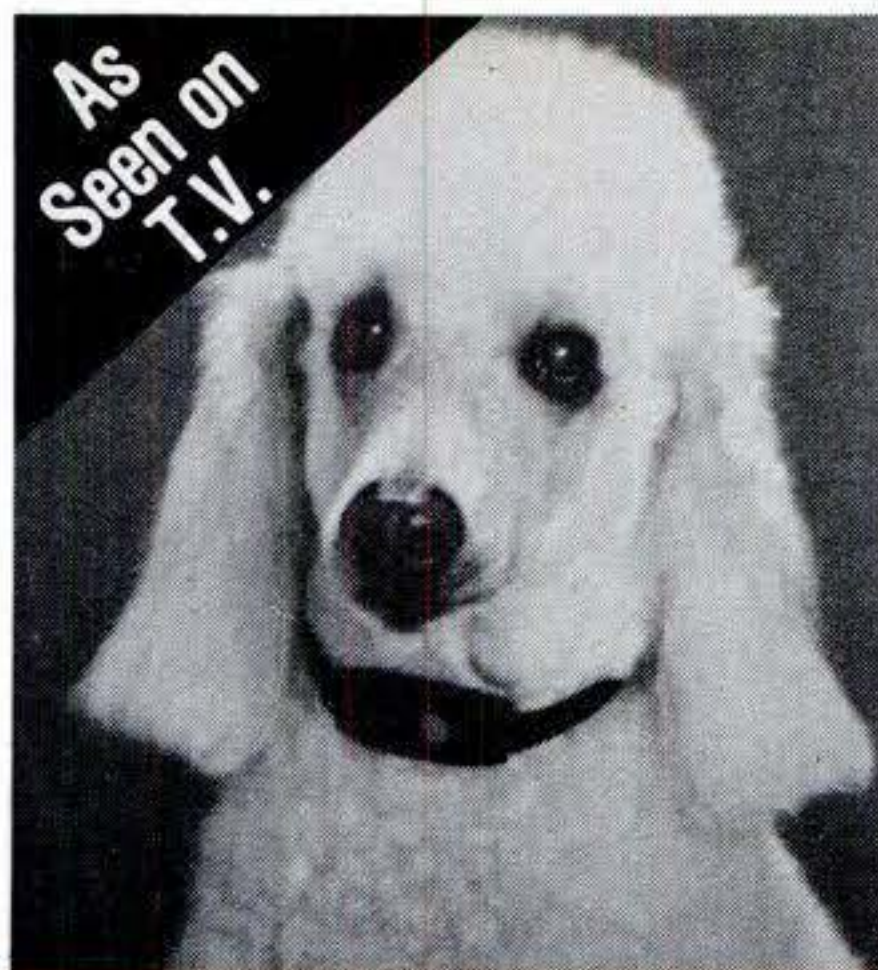


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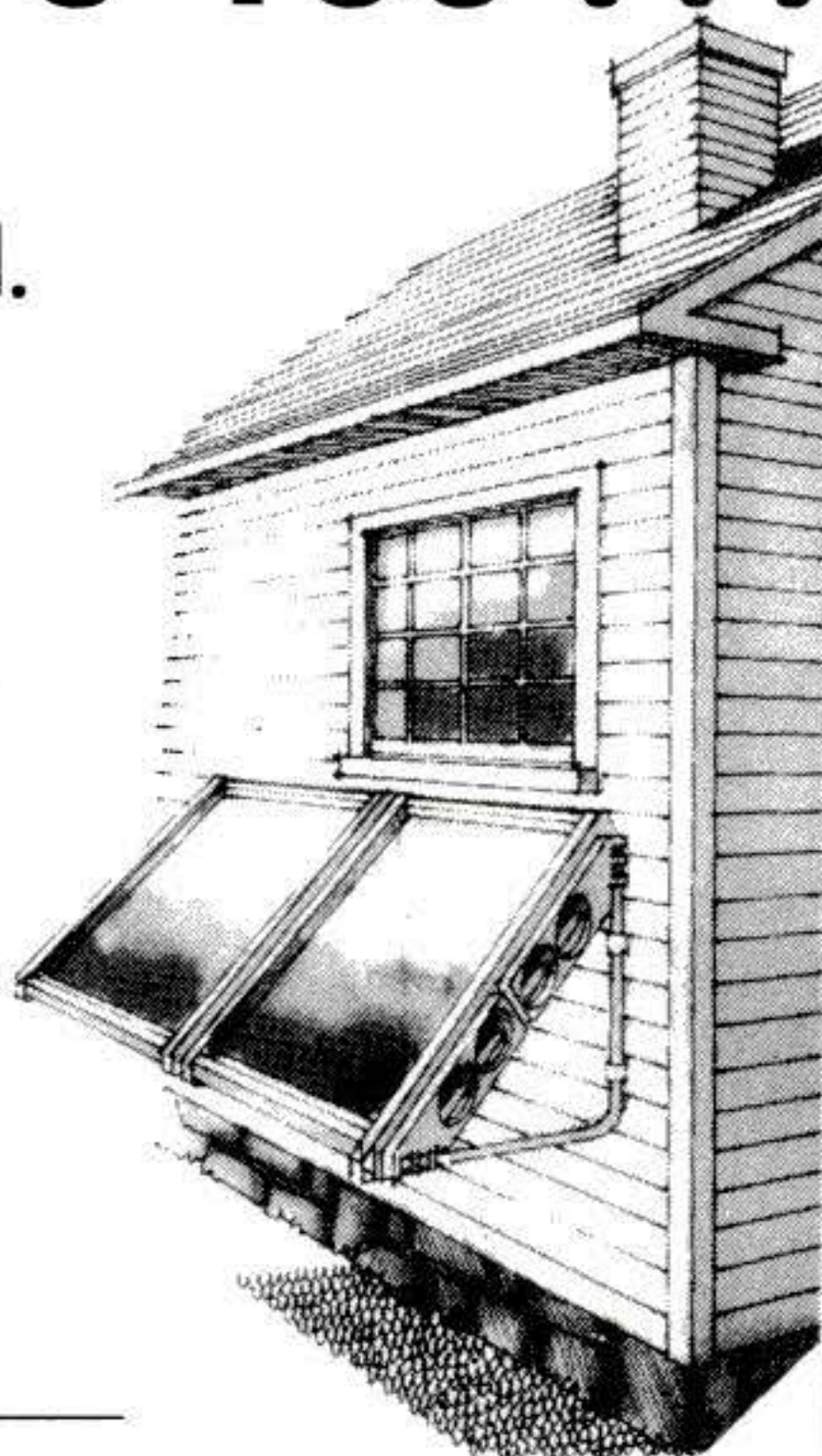
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Push-pull windmill

[Continued from page 87]

speculates, by religious zeal—threatened, then acted. "They smashed it several times," he says, wincing. "Again and again I rebuilt it, but they kept coming after it. Finally, I moved to Chicago."

Other projects are in the works, though. One, scheduled for 1986, is a 16-foot-high, 50-kW unit for a turkey farmer who has a \$1,000-a-month electric bill. At \$50,000, Herrmann calculates, electrical production over the windmill's lifetime will run about four cents per kW. Another project is a prototype turbine that he plans to build atop downtown Chicago's Avondale Building.

An additional possibility is a one-megawatt 170-foot-high tower built into an apartment building near Boulder, Colo. Such a tower is expected to produce 50 kW at 10 mph, 440 kW at 20 mph, and 3.5 MW at 40 mph. Herrmann estimates that it would cost between \$1 million and \$3 million, with a possible payback period of three years—pretty heady figures.

Maybe too rosy, say some other engineers in the wind-generator field. One, for instance, is Barnes W. McCormick, former head of Penn State University's aerospace engineering department. "The concept is a very interesting one," he says, "but I feel that the claims about its performance may be overdone. The figures that Herrmann quotes exceed by a wide margin the capabilities of the best wind turbines now operating." Most experts in the field agree that it's simply too early to discern the performance of the engineer's design.

Herrmann is also planning smaller units for summer and remote-site use. A unit to produce an average 6 kW could cost in the range of \$5,000 to \$10,000.

But the United States is probably not sufficiently windy for widespread use of Herrmann's machine. The long-term market for the device, he suspects, is abroad. Developing countries need energy, but, as yet, windmills haven't been very successful. The main reasons are poor maintenance and overly high winds—winds on which Herrmann's Venturi Rotor is designed to feed.

"Now, the Falkland Island chain," says Herrmann enthusiastically, "that's windy, with something like a forty-mile-per-hour average." Most turbines are designed to stall when the wind gets much above 40 mph, or they'll fly apart. That's one reason you don't see them in places you would expect to—Greenland or South American countries. But the Venturi Rotor is designed to gobble up the energy of a windstorm.

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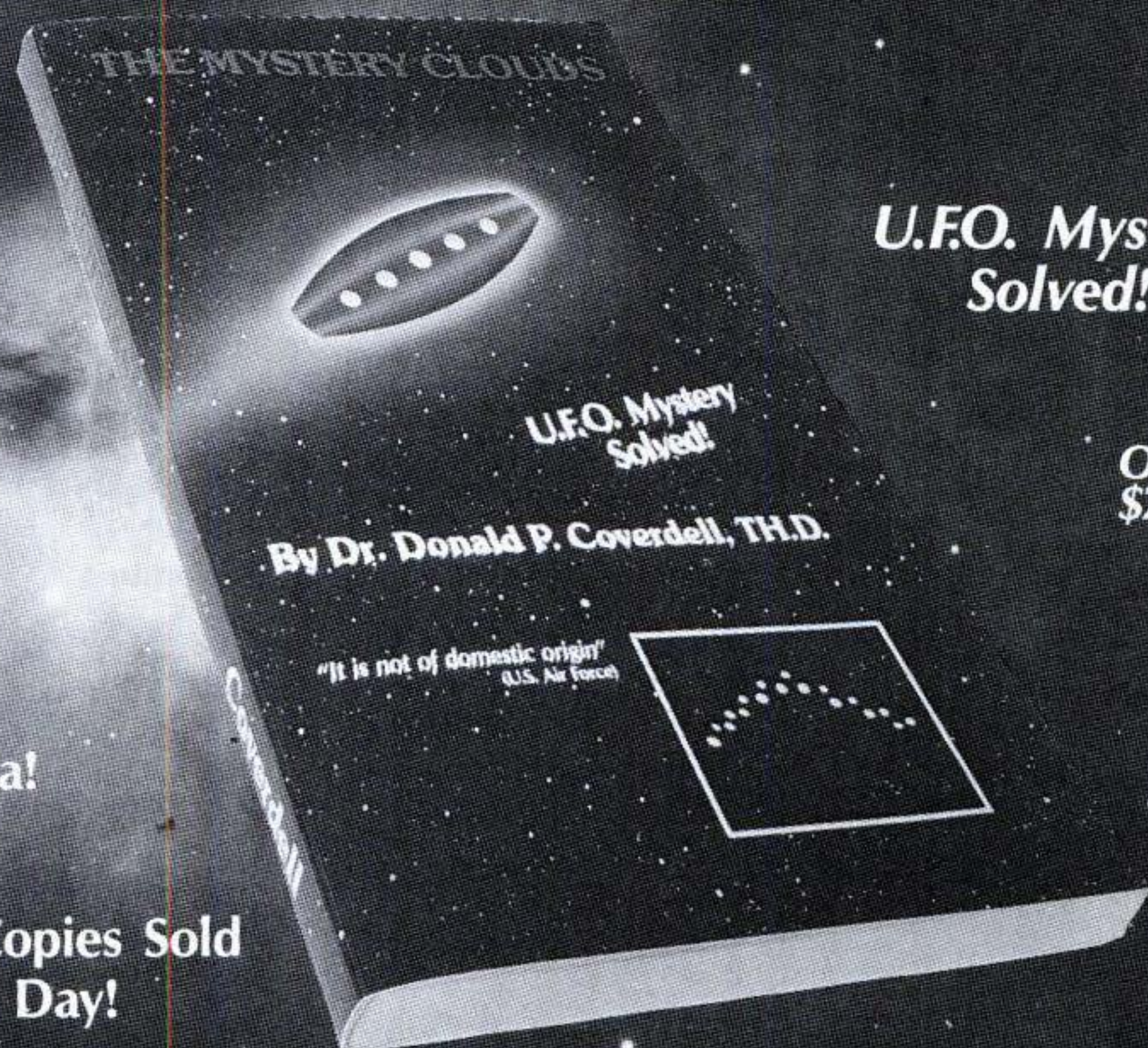
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Uranus! [Continued from page 81]

Its two most astounding features will be studied by planetary geologists for years. In the north there's a huge circular basin, bounded by a deep trench. The basin appears to be cut and etched "like a stack of flapjacks, with ever-decreasing size as you go up the stack," Soderblom said. It faces directly toward Uranus. Soderblom found that potentially significant.

In the south, Miranda displays one of the solar system's most curious features—a bright, lightly colored chevron of material emblazoned into the surface and bounded by linear fault systems. The chevron seems to be a massive ice flow exuding from Miranda's interior, perhaps triggered by impacts puncturing its icy crust.

"Miranda is an extraordinary hybrid," Soderblom said. "If you took all the bizarre geological features in the solar system and put them on one object, you'd get Miranda."

The 10 new moons discovered by Voyager are small—10 to 20 miles in diameter. Like most of the material in the Uranian rings, they are too dark to reflect much light. Spotting them at all was like "photographing a lump of coal against a black background," said JPL's Terrile.

A series of surprises

With Voyager's cameras stymied by the blank face of Uranus itself, the craft's sophisticated collection of other instruments—magnetometers, infrared and ultraviolet sensors, radio receivers, plasma and cosmic-ray detectors, and more—probed the planet and its environment. What they found sent scientists scurrying for new theories on planetary physics and the events that occurred in the outer solar system 4.5 billion years ago.

One surprise followed another. Looking for a giant aurora with his ultraviolet sensor, Dr. A. Lyle Broadfoot of the University of Arizona found a totally new phenomenon he called "electroglow." The glow, triggered by electrons interacting with molecular hydrogen, bathes the sunlit side of Uranus, he said, not the dark side. But its energy source remains unknown, perhaps waiting to be discovered in the mounds of data yet to be analyzed.

Yet another surprise followed from a brief announcement by project scientist Dr. Edward Stone just one day before Voyager's closest approach. "Yes, there is radio emission from Uranus," he said. It was the first clue that Uranus has a magnetic field, and it gave scientists hope that they would be able to deduce much about the planet's interior.

They got more than they bargained for. Less than two days later, Dr. Nor-

man Ness of NASA's Goddard Space Flight Center revealed a major discovery by Voyager's magnetic-field instruments. "What I have to report is reflective of a new world," he said. Not only did his instruments record a strong magnetic field surrounding Uranus, but his data showed the planet's magnetic axis is tilted 55 degrees from the north pole, far more than any other planet. That gives the field a distinct wobble as Uranus spins on its north-south axis. The finding allowed Ness to calculate that the planet's rotation rate is 16.8 hours.

"The conclusion is inescapable that there is a mechanically stirred liquid interior," Ness said. That kind of planetary core must also be generating some heat and affecting Uranian weather on a global scale.

Within weeks Voyager data indicated that Uranus has more than a molten core. Its clouds may be concealing an intensely hot ocean of water 5,000 miles deep. That ocean could be the melted remains of millions of primordial comets swept up from the far reaches of the solar system in the earliest days of planetary formation. Trapped and prevented from boiling by the pressure of a methane, helium, and hydrogen atmosphere thousands of miles thick, the churning ocean and slowly rotating molten core could account for the tilted magnetic field.

The wobble also may have major implications for other phenomena reported by Voyager. For instance, data showed that the narrow ring system of Uranus is virtually devoid of both dust and small pebble-sized chunks of material. Astronomers had expected to see the rings brightly illuminated by forward-scattering sunlight reflected from dust after Voyager passed the planet. Instead, they found the rings to be even darker. By measuring radio transmissions passing through the rings, they determined that the rings are composed mostly of ice boulders measuring three feet or more in size.

The finding surprised them. There is dust in the rings at Jupiter and Saturn. Why not at Uranus?

The wobbling magnetic field provided one theory. "Imagine what happens to satellites or dust moving across a whole range of magnetic lines," University of Arizona's Smith speculated. "You get a complicated interaction." The result could be that dust particles become so charged that they are swept up by the larger ring chunks or dispersed out into space.

Uranus itself showed few visible features. In a false-color image, with hues dramatically enhanced, a ring of reddish-brown smog appeared around the

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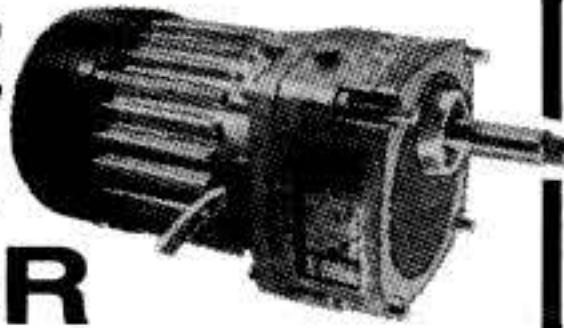


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Uranian south pole. The ring, said Smith, may be caused by upwelling clouds carrying particulate matter from below.

What the clouds say

Looking closely at true-color photos of the blue-green globe, Smith spotted a few faint white clouds in the upper atmosphere. The clouds were reminiscent of similar features starkly visible on other planets. "It's nice to see an old friend," he quipped.

Photos on successive days showed the clouds carried along by high-altitude winds, circling the planet in 15 to 17 hours. It was clear evidence that Uranus has some kind of weather. The clouds, Smith said, are convective cores climbing high enough to be plumed out by the winds. That phenomenon, he said, usually means that temperatures are decreasing from the equator to the pole. But that's not true on Uranus, where the south pole is facing the sun and should be warmer.

Yet as Voyager's instruments reported their findings, the truth proved the theories wrong. Temperatures at the sunlit south pole were not warmer than at the equator, rather they were virtually identical. Even stranger, the dark north pole was slightly warmer.

"Something is heating that atmosphere," Stone said. "But we don't understand what it is." One possible answer is the deep ocean, itself heated to thousands of degrees.

Uranus's high-altitude winds may also provide part of the answer. Measured at 300 mph by tracking the faintly visible clouds, the winds blow around the planet in the same direction it rotates. That was another surprise. Because Uranus is tipped on its side, theory called for the winds to blow in the opposite direction.

"The Uranian atmosphere is obviously more complex than we thought only a few days ago," Smith said.

By early February, Voyager moved deeper into the dark, its trajectory bent by Uranian gravity onto a new track through space. While the veteran explorer soars outbound, scientists will study the thousands of photos and miles of data tape it provided, hoping to unravel what they can of the puzzles, old and new, from the Uranus encounter. And they'll be thinking ahead, toward an August day in 1989 when Voyager skims into the realm of Neptune for one last encounter with a home-system planet.

Stone, on the Voyager project since 1972, summed up the ongoing grand tour this way: "Our idea of Neptune will clearly be influenced by what we've seen at Uranus. Ask me more in three years."



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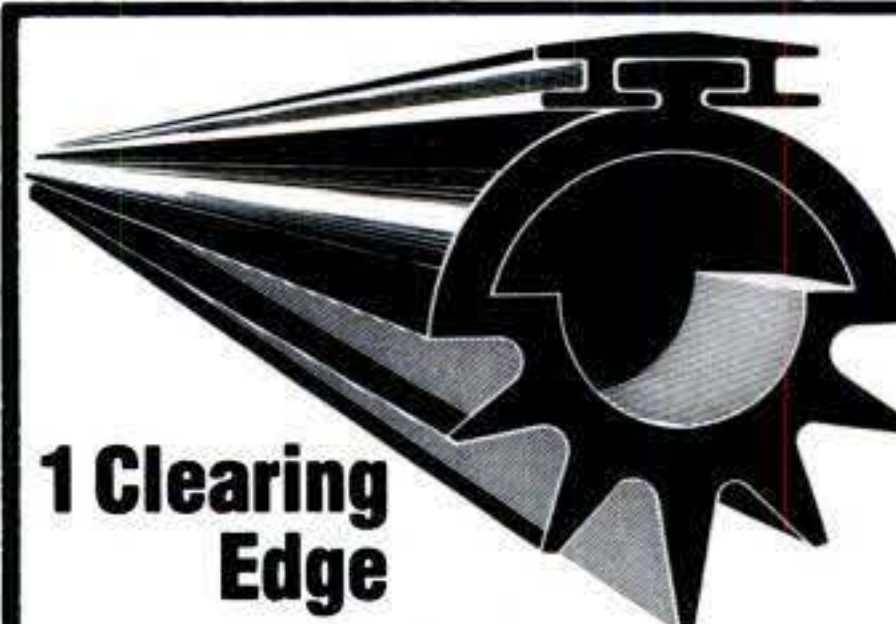
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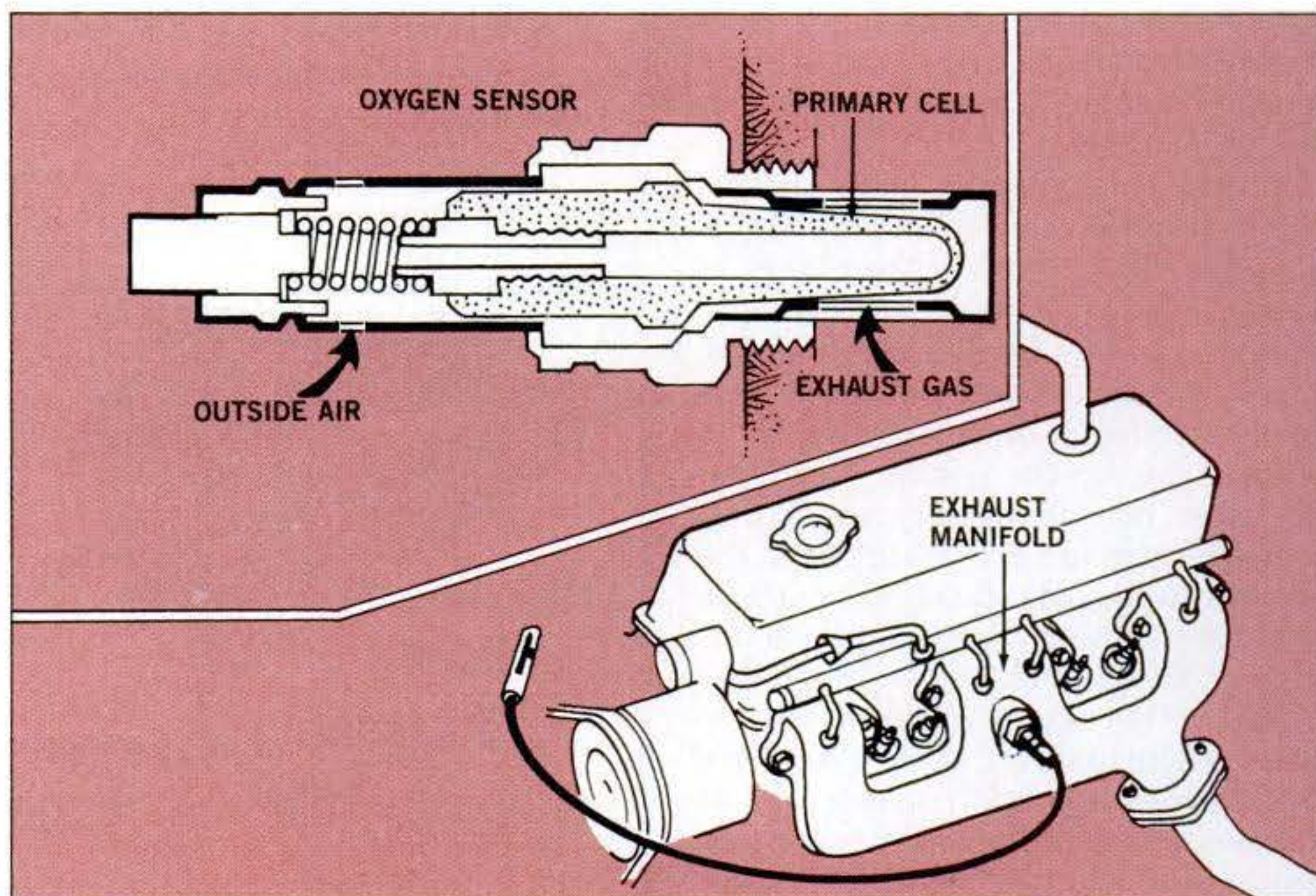
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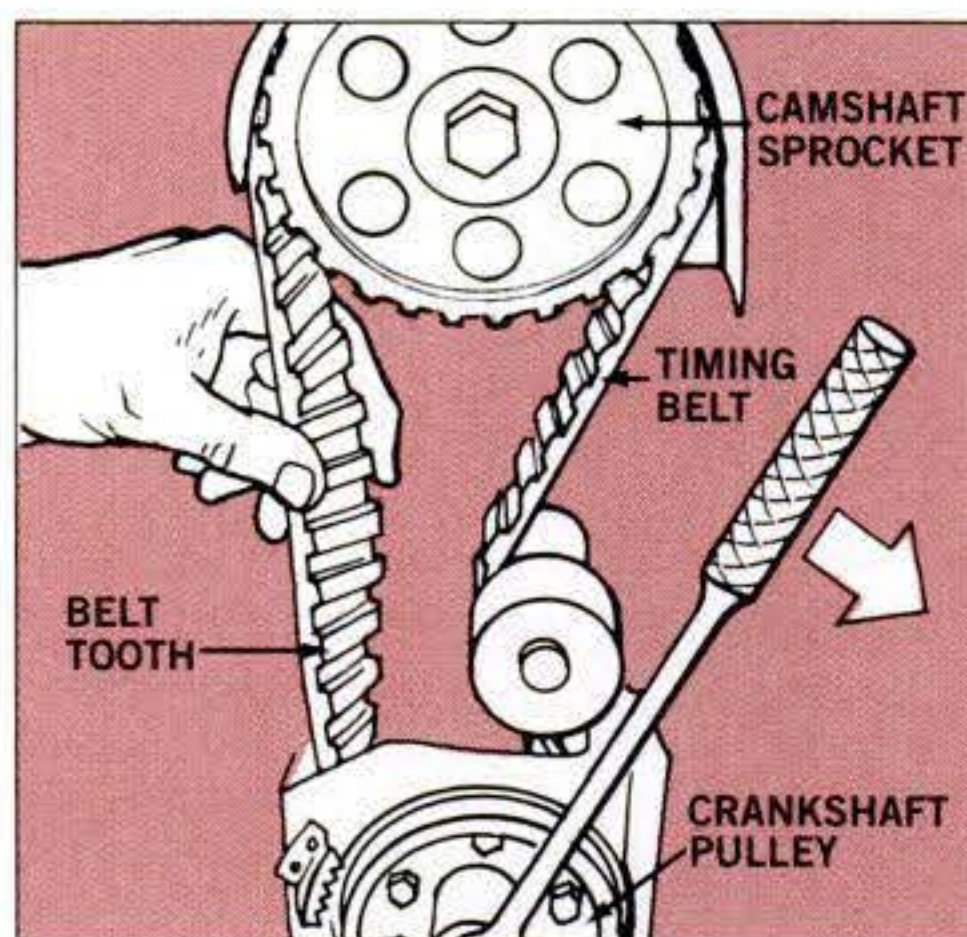
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Cleaning an oxygen sensor

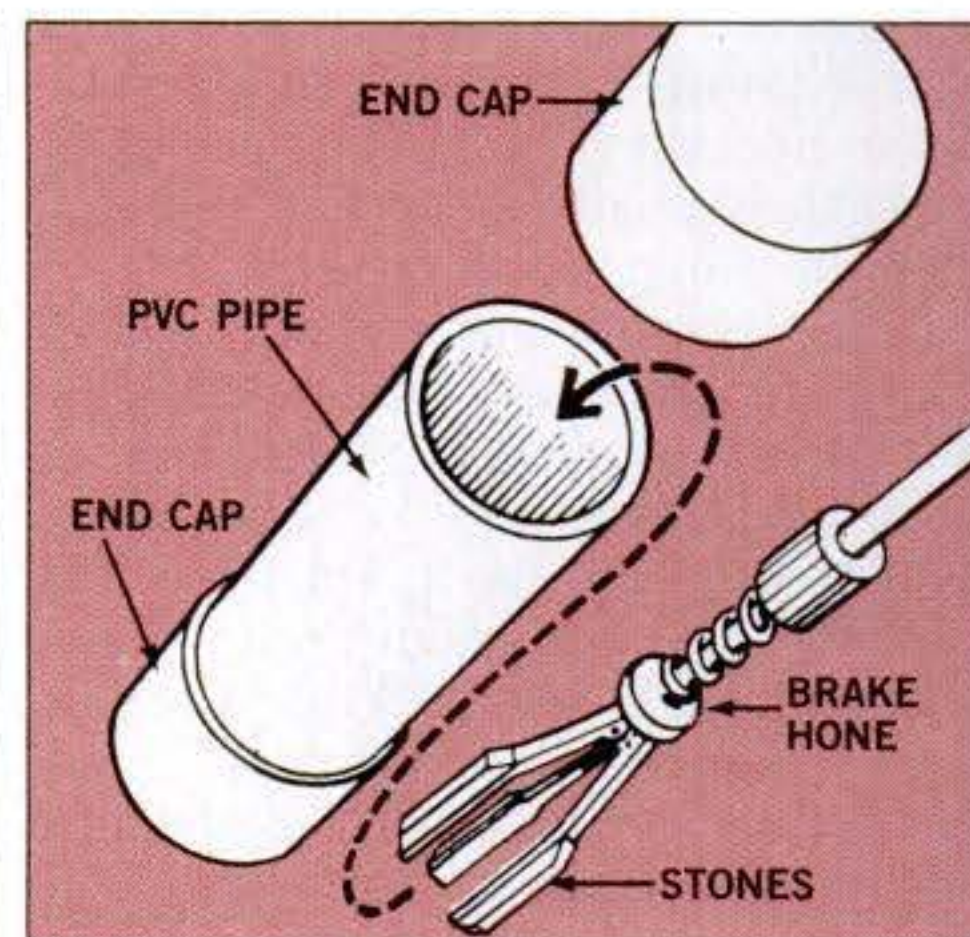
Most late-model cars use an oxygen sensor in the exhaust manifold to measure oxygen content in the exhaust gas. This enables the vehicle's on-board computer to adjust the air-fuel ratio for the most efficient combustion. The sensor reads the air-fuel ratio by comparing the exhaust-gas oxygen

content with the atmosphere's oxygen content. Because the sensor must also measure outside air, it's important to keep the sensor's exterior clean. Use a clean rag or soft brush to remove outside contamination. Note: Avoid using strong chemicals or high-pressure air to clean the sensor.



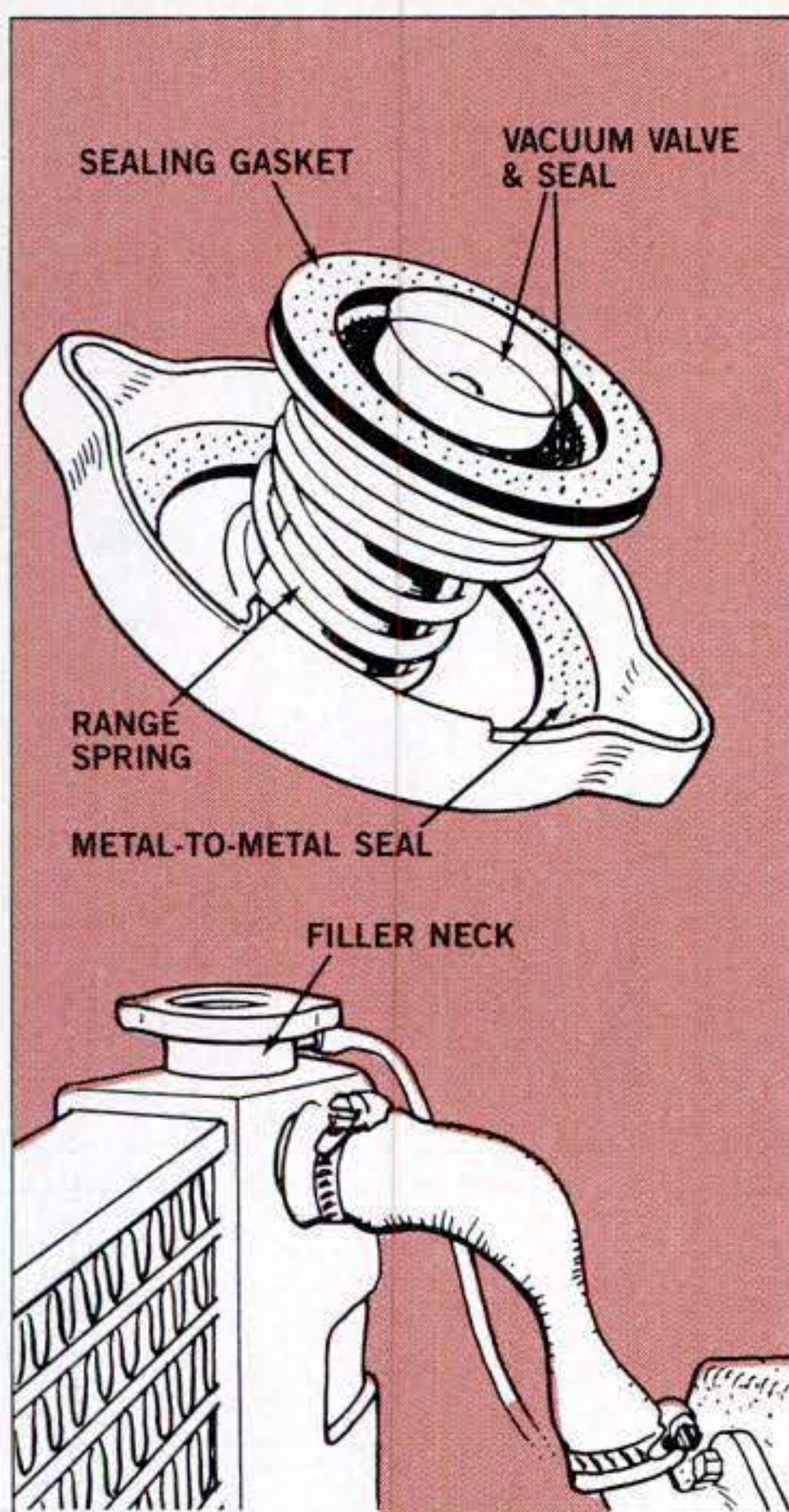
Timing-belt checkup

During a routine tuneup, it's a good idea to check an overhead-camshaft's timing belt. First, remove the belt cover. Then, with the spark plugs removed, install a breaker bar and socket on the crankshaft pulley. Now rotate the engine slowly, looking for missing teeth, loose fiberglass strands, unusual wear, or oil on the belt.



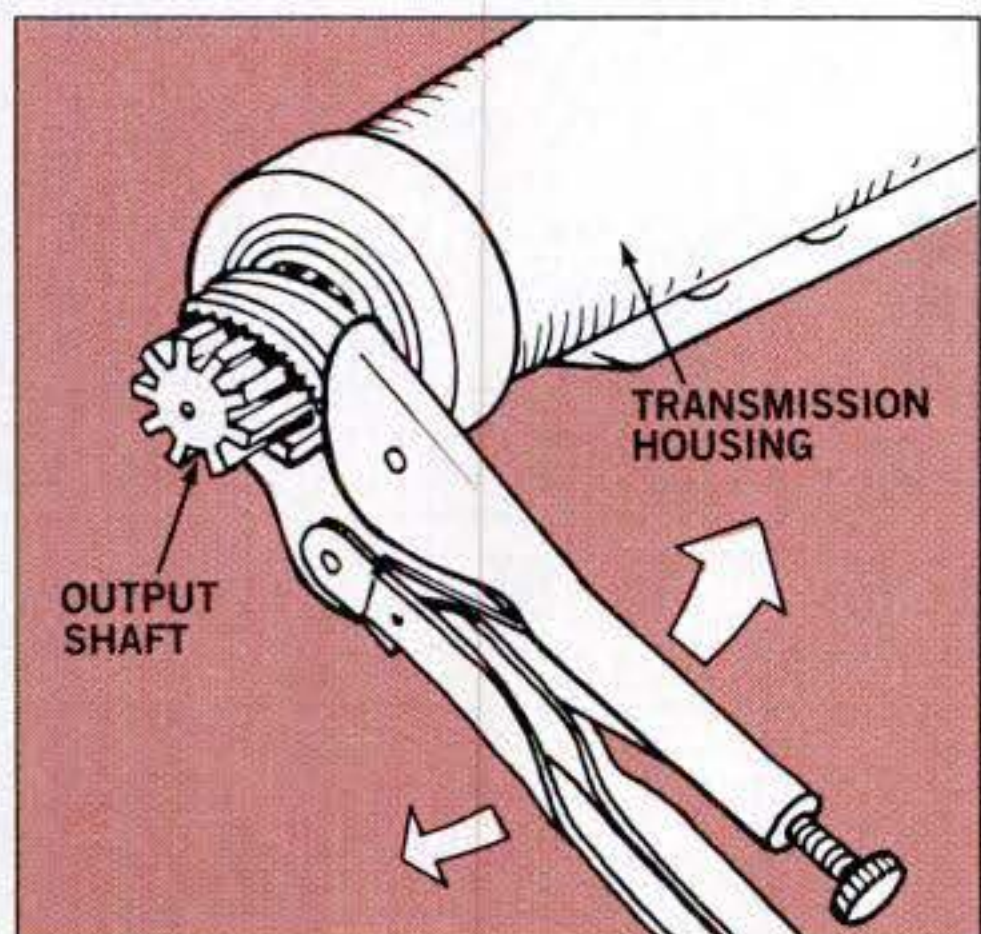
Hone home

A toolbox can be a hostile place for the fragile stones on a brake-cylinder hone. To protect them, try this: Glue a cap on one end of a piece of one-inch PVC pipe. Now slip the hone inside the pipe. The spring action of the hone's arms will hold the tool safely in place. Press another cap onto the other end of the pipe.



Collapsing hose

If the upper radiator hose collapses after an engine has cooled, check the radiator cap's vent valve for a clog. A clogged or damaged valve will not allow pressure in the cooling system to equalize as the engine cools. Replacing a damaged cap or cleaning the cap vent will lick the problem.



Tranny trick

Installing a manual transmission is frustrating when the input shaft's splines refuse to mate with the clutch-plate splines. To ease reassembly, place the transmission in high gear, then clamp locking pliers onto the gearbox output shaft. Use the pliers to rotate the output shaft as the input shaft enters the clutch.

MUST LIQUIDATE E-X-P-A-N-D-A-B-L-E Leather Briefcases

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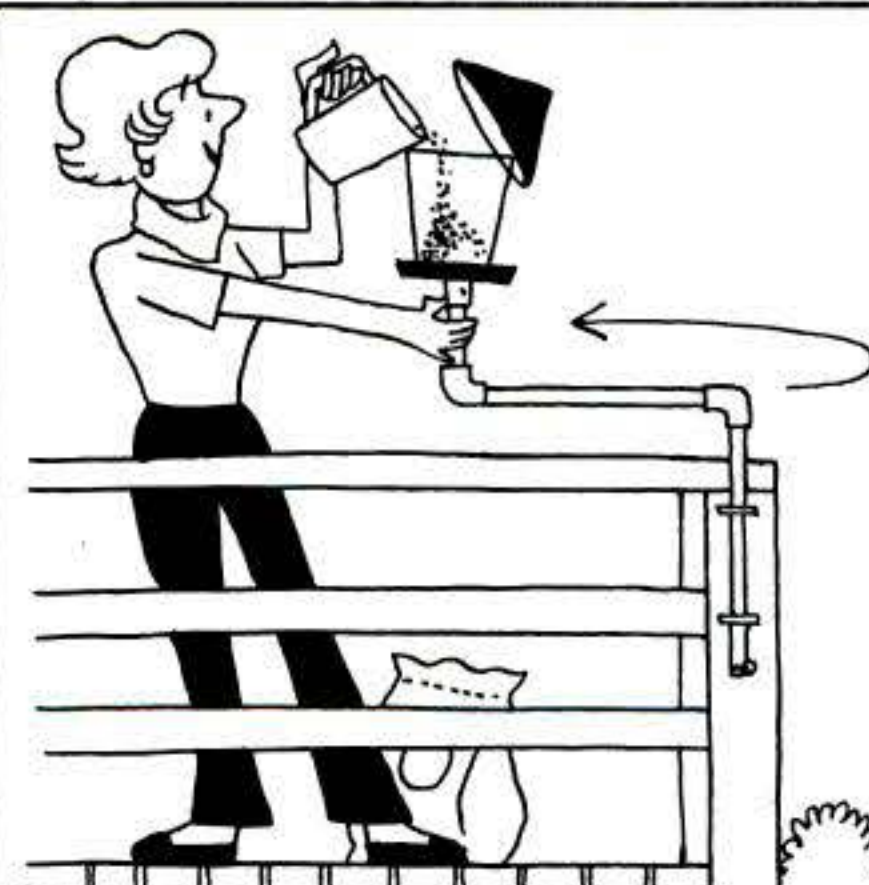
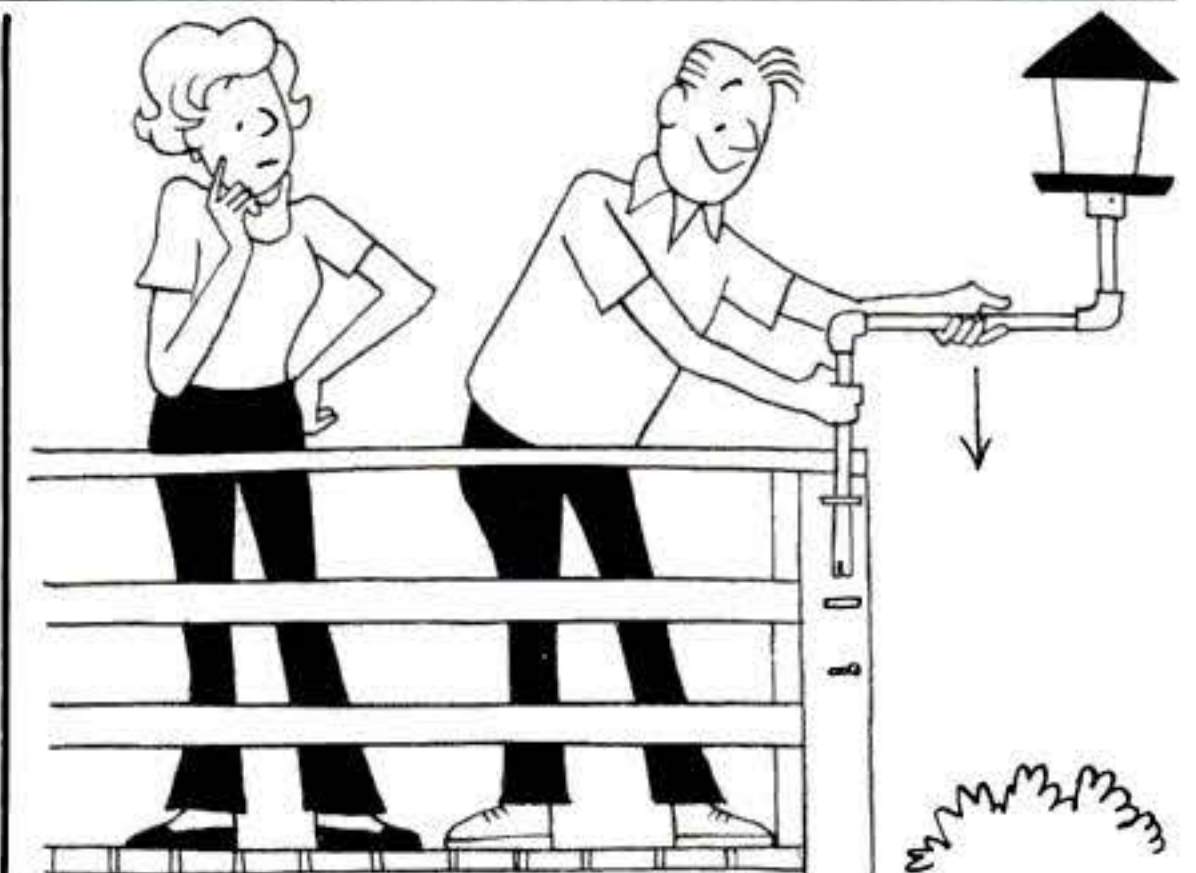
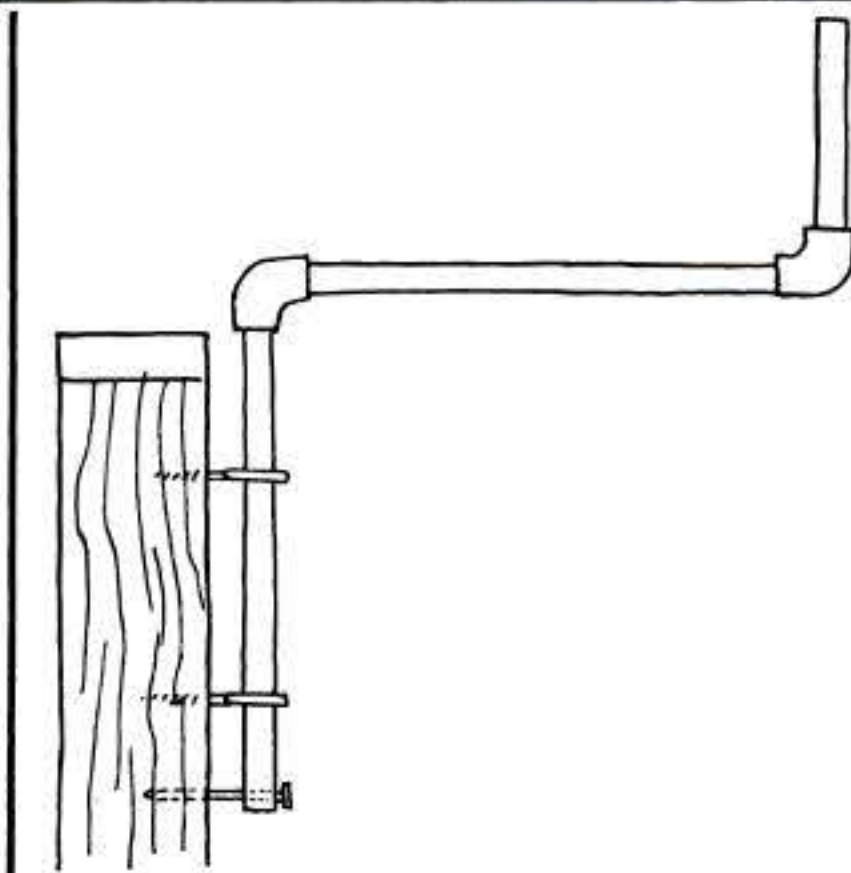
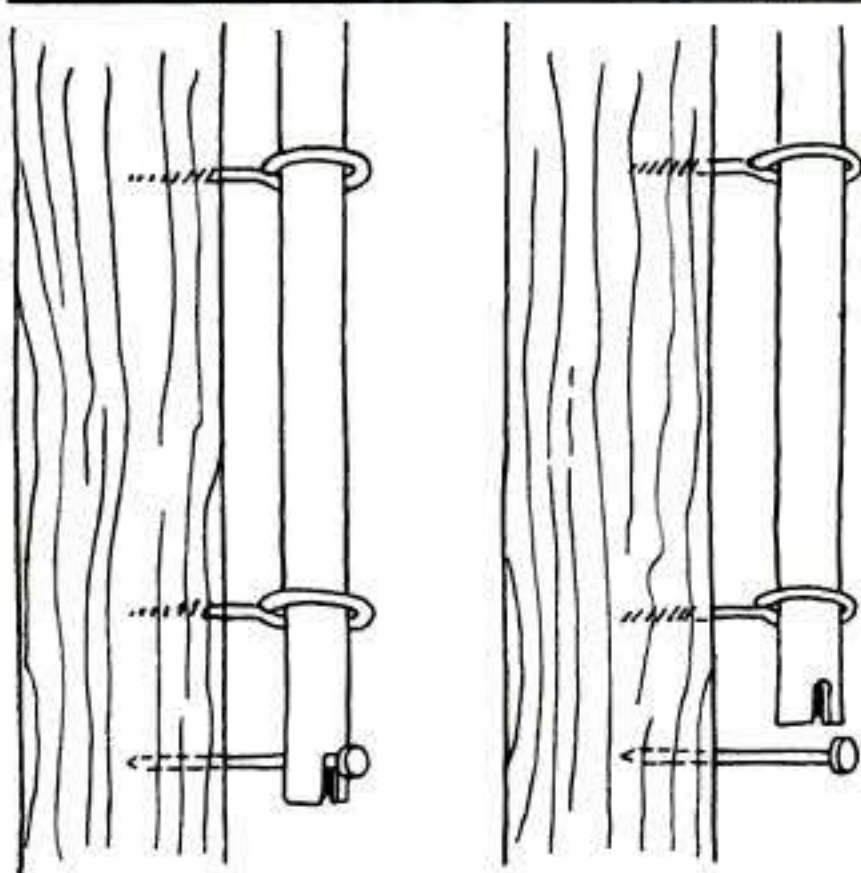
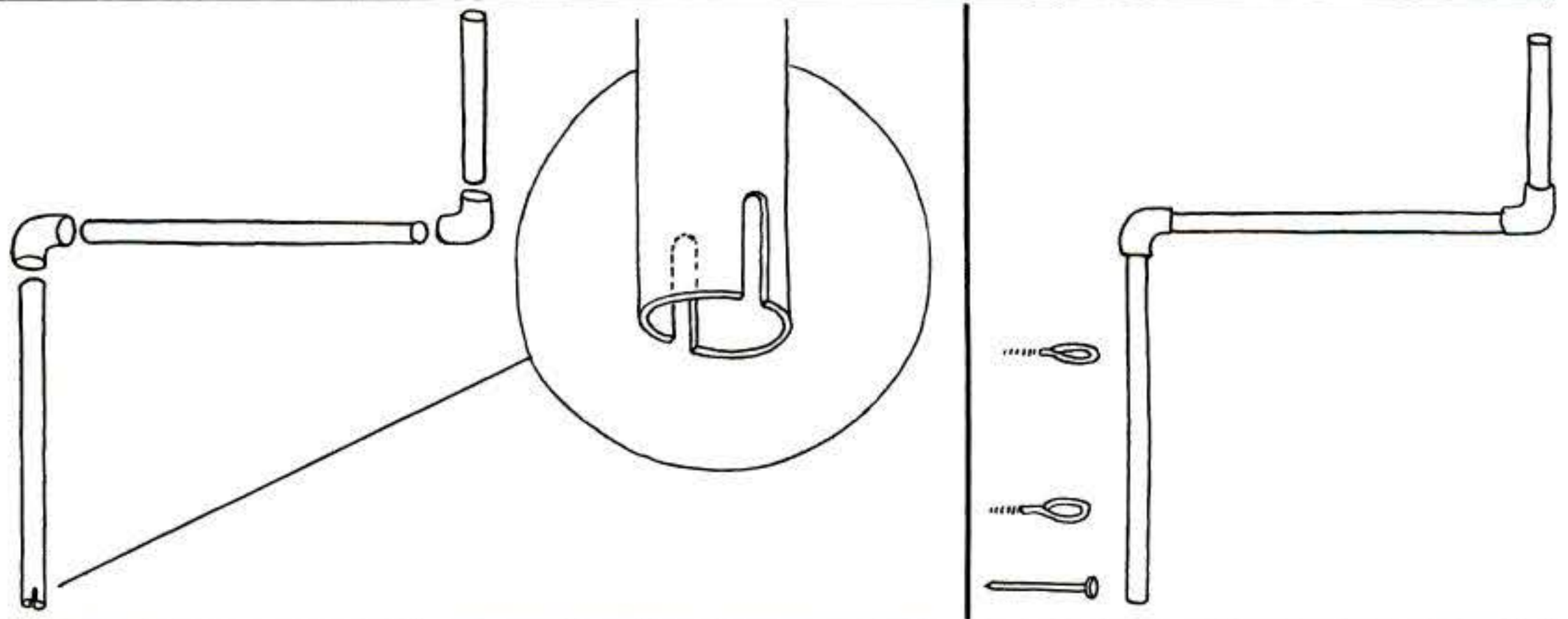
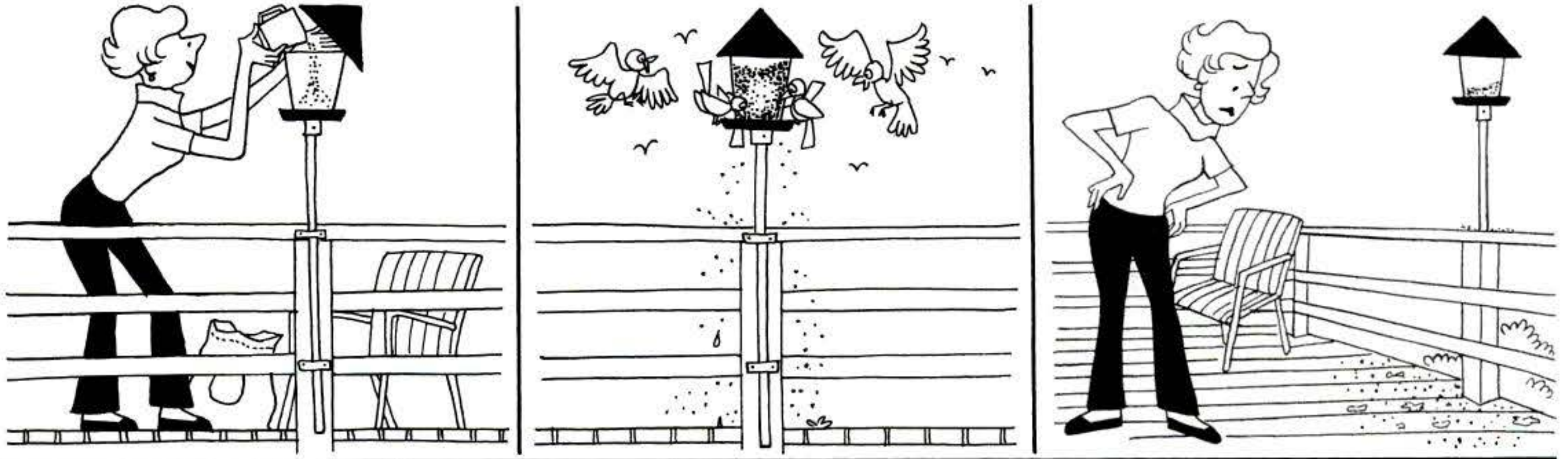
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By ROY DOTY

\$50 to John Marszalek of Gaithersburg, Md., for this idea. Send yours (with Social Security No.) to Wordless, POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. Only purchased ideas can be acknowledged.



YOUR CAR'S ENGINE WILL WORK BETTER; LAST LONGER WITH TUFOIL®

—you'll spend less to run the car you now own.

Patented Tufoil Technology, using PTFE increases engine life...does much more!

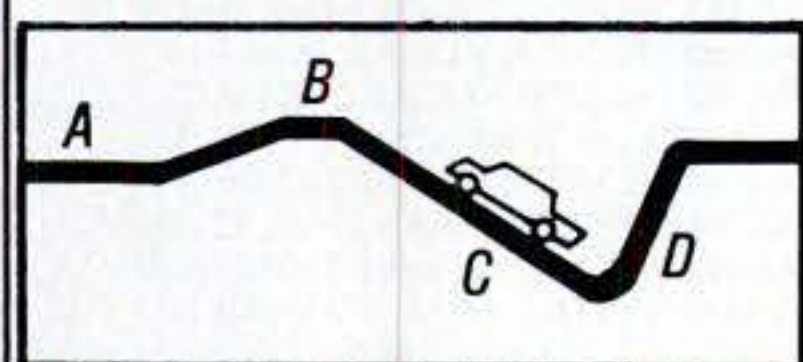
Tufoil with polytetrafluoroethylene (PTFE) improves horsepower and MPG while drastically cutting engine wear and repair bills.

How? By dramatically reducing your engine's internal friction and operating temperature. Now you can get much longer life from your car's engine *and* save hundreds on gas. Many Tufoil customers are reporting astonishing performance results!

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Chart shows how Tufoil improves your engine.



A - New Car
B - Performance after break-in period
C - Performance declines with age and mileage
D - Dramatic improvement with Tufoil

Tufoil turns your motor oil into a super lubricant, protecting all internal engine parts.

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In any weather, throughout their entire performance range, engines with Tufoil run easier.

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...that Tufoil® is better than other lubricants...the list keeps growing.

1. Six U.S. and a number of foreign patents have been awarded to Fluoramics for Tufoil®... more are pending.
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3. In Canada, government tests show a big improvement in low temperature starting for gas and diesel engines with Tufoil® (5% fuel savings).
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8. More and more police departments and racing drivers are switching to Tufoil® to save engine wear and fuel for faster friction-less starts.
9. We've had many customers tell us Tufoil® gives astonishing improvements to their engines. Over the life of your car, this translates into thousands of dollars saved and tens of thousands of extra miles added.

cold weather, your engine will start quickly and easily—even in sub-zero temperatures, so your battery works less and lasts longer. Whether you drive long distances at high speeds...pull heavy loads...or stop-and-go in city traffic, Tufoil® protects your engine best. It's the most sophisticated engine lubricant ever developed for your car.

Most engine wear and damage occurs during starting. This is where Tufoil really makes the difference.

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NO RISK FREE TRIAL OFFER MONEY-BACK GUARANTEE

We guarantee that Tufoil works as promised and that you'll notice the terrific results immediately. We dare you to give Tufoil a run for your money. It's easy. Just follow directions carefully and add Tufoil the next time you change your oil.

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If you're not satisfied, simply send us proof of purchase with a note and we'll refund your money immediately—no questions asked.

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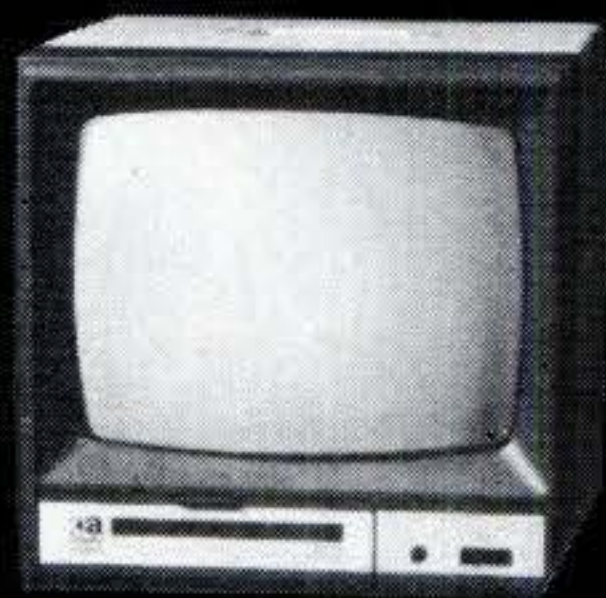


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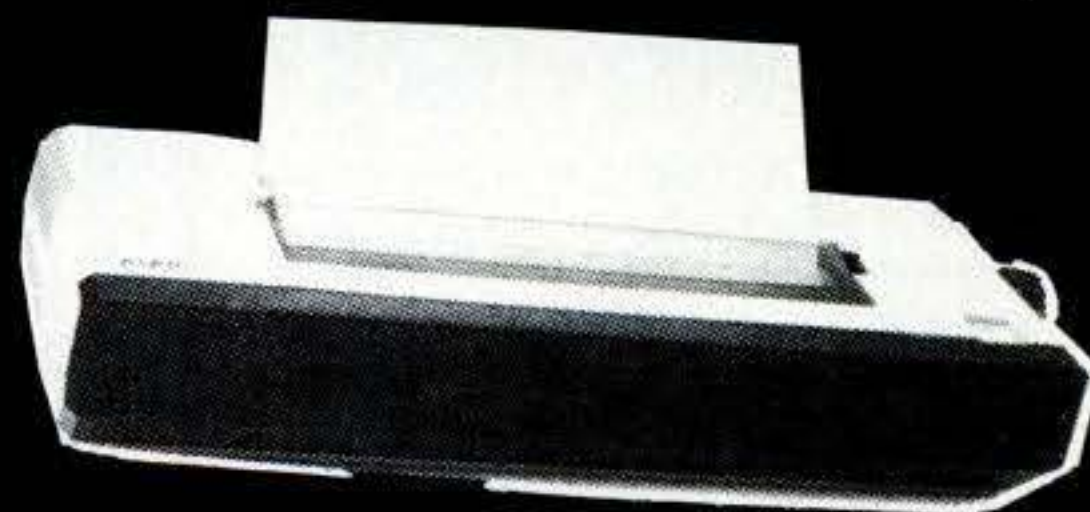
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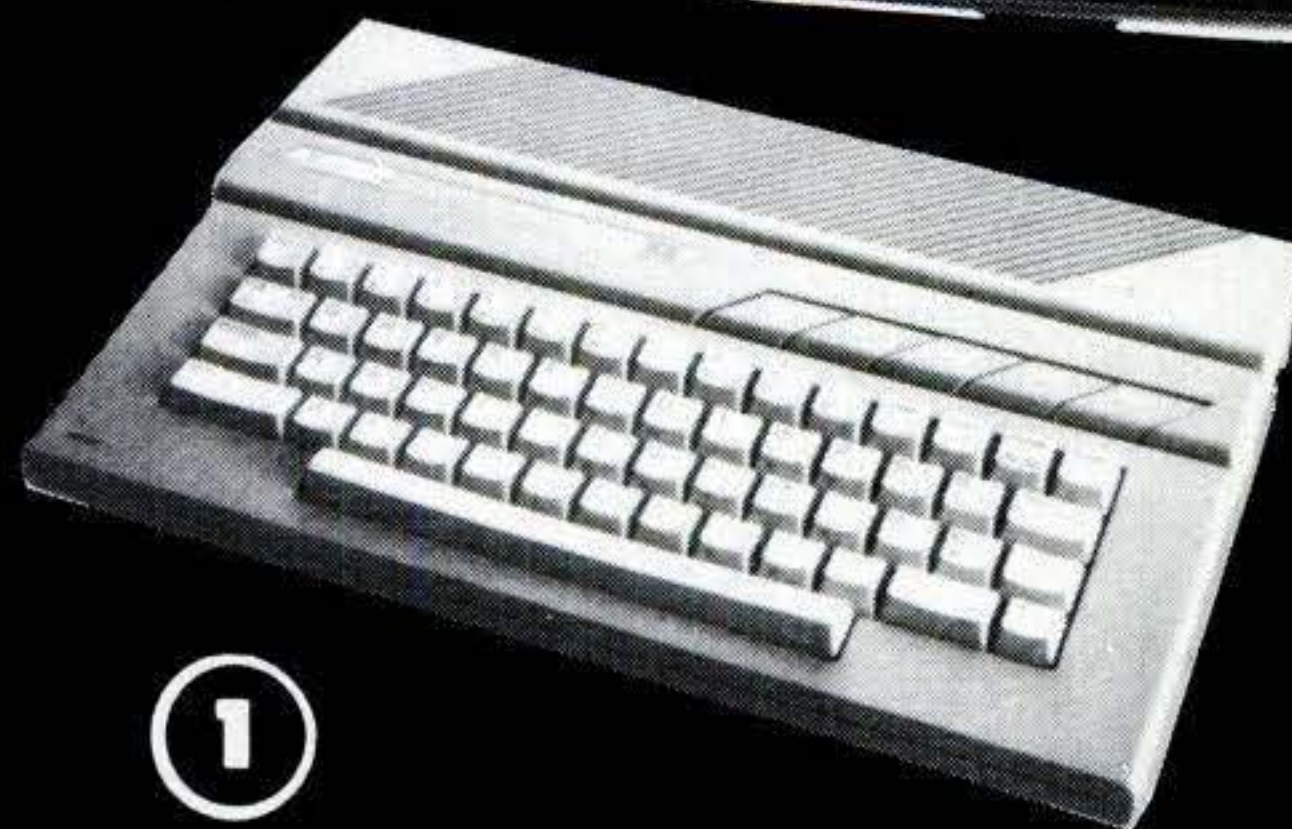
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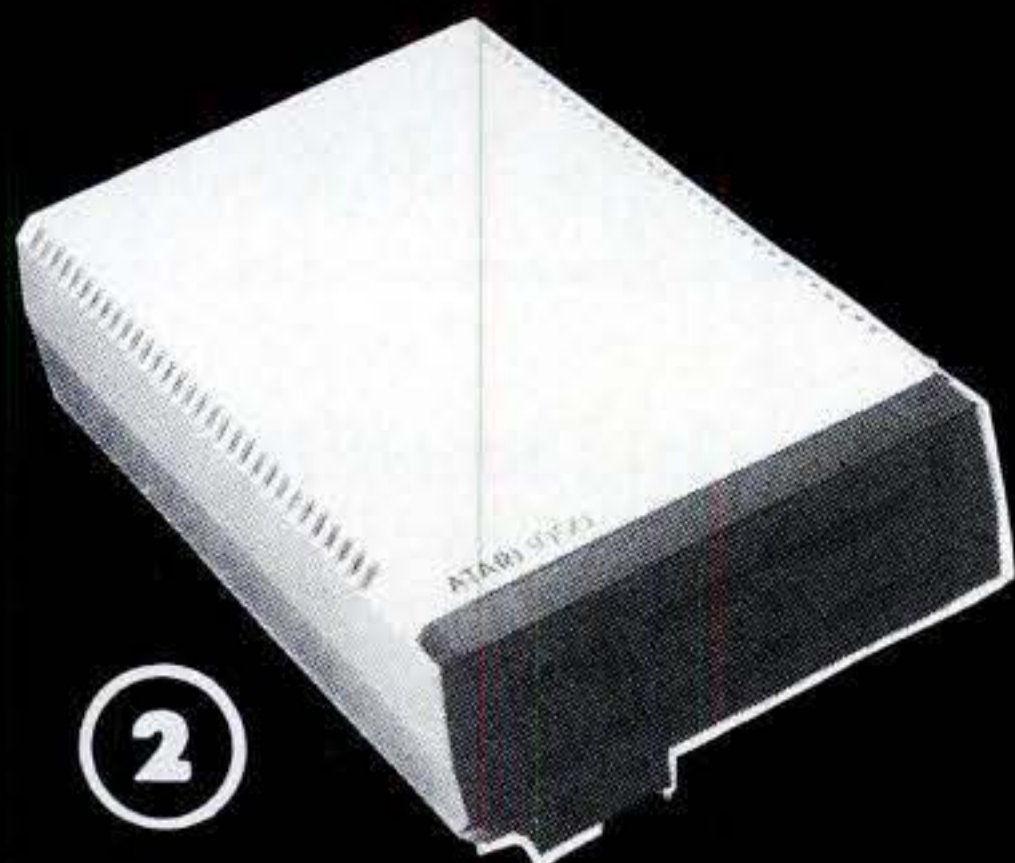
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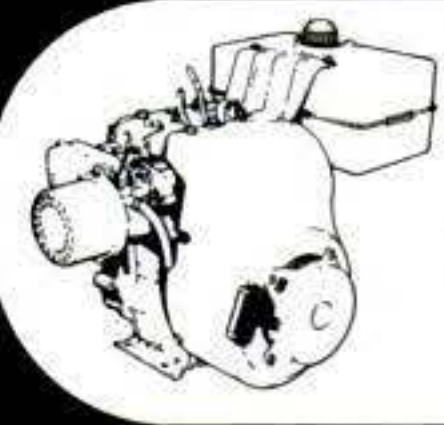
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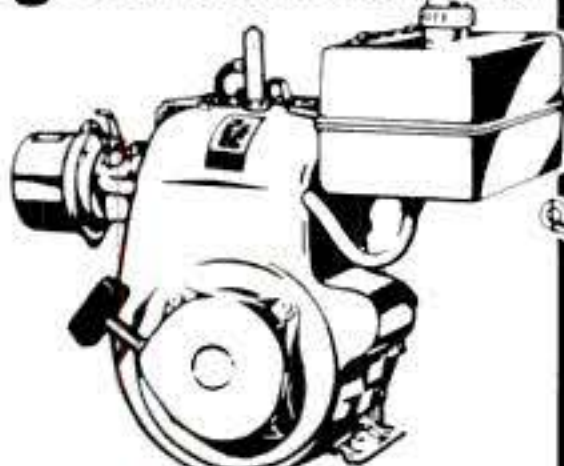
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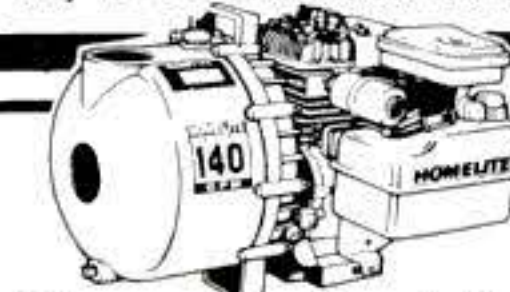


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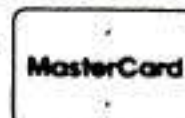
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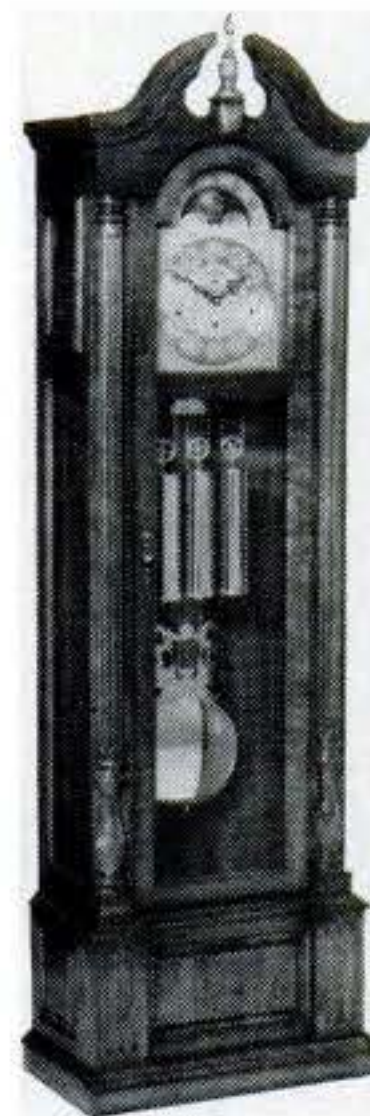
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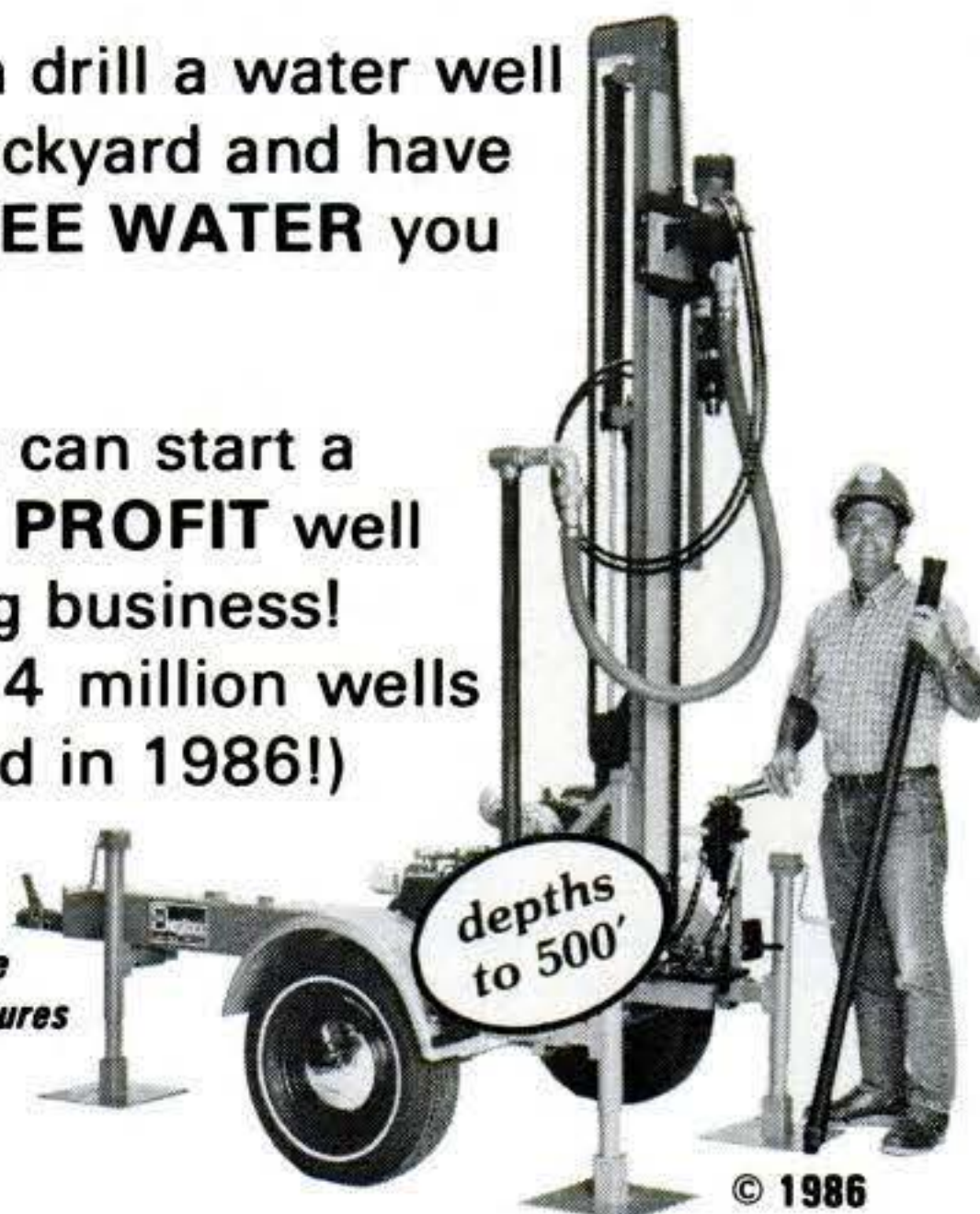


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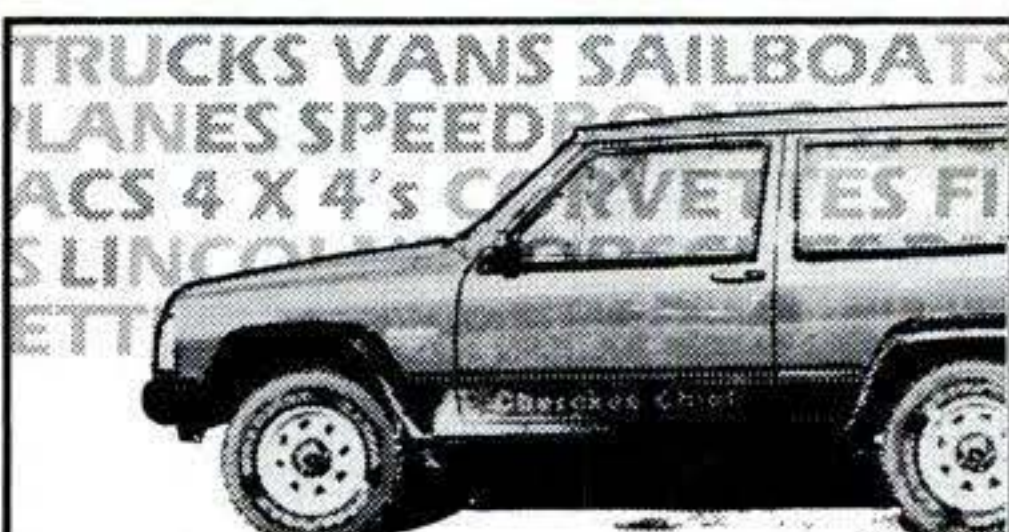
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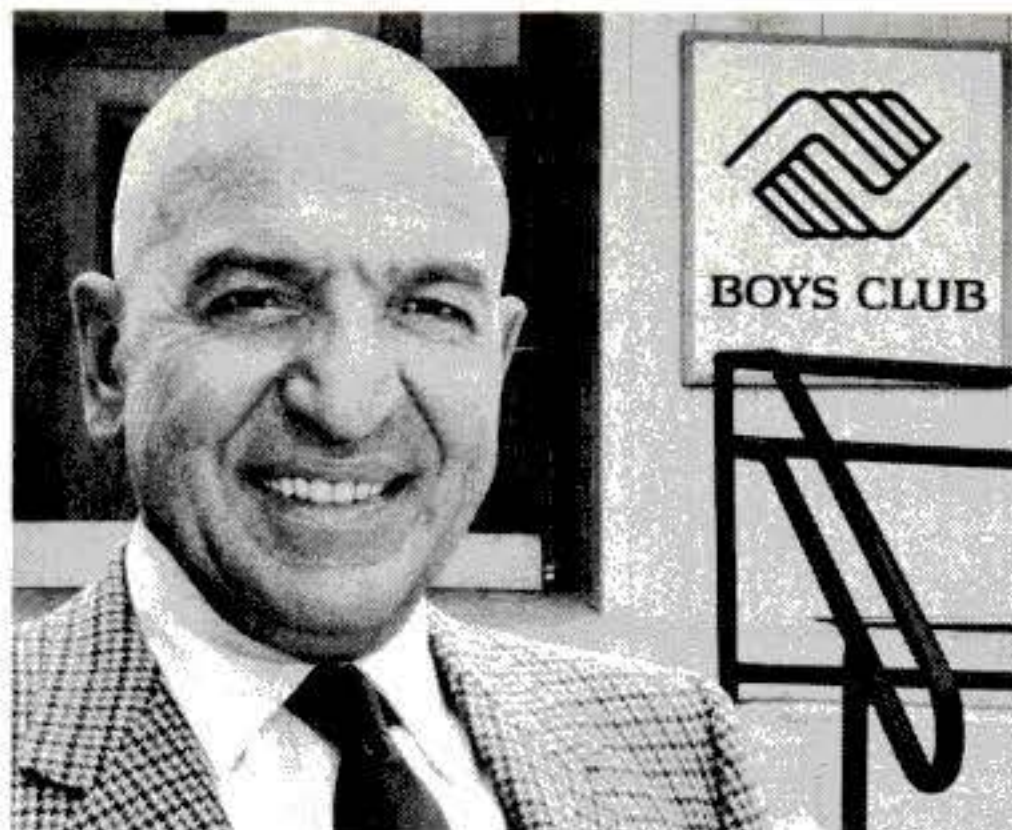
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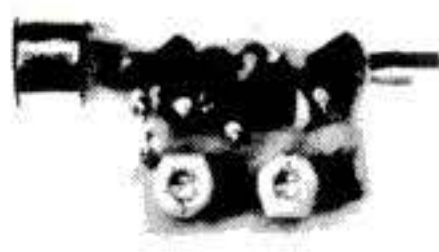
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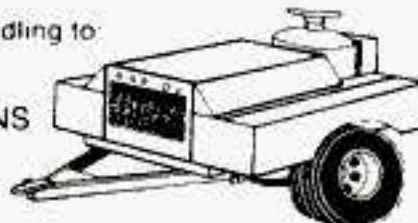
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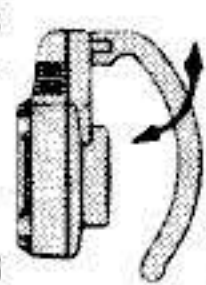
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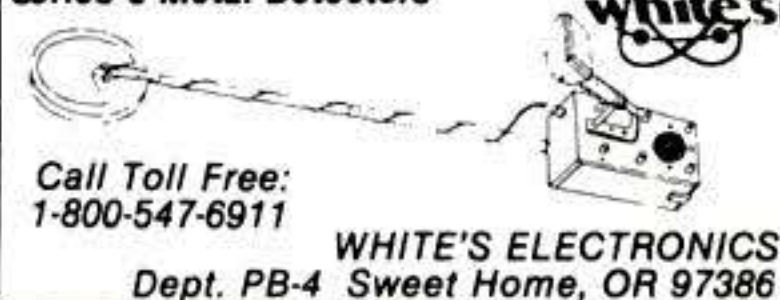
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